SCI/TECH

Plants do some very clever things, scientists say

Leslie Sieburth/University of Utah

University of Utah graduate student Jaimie Van Norman holds a tray of experimental weeds that show how plants' genes enable them to cope with cold, drought and other stresses.

BY ROBERT S. BOYD
Knight Ridder Newspapers

WASHINGTON — People don't usually associate intelligence with weeds or cabbages. But plant scientists, taking advantage of new genetic information, have discovered a surprising level of what looks like brainy behavior in the vegetable world.

"It's amazing what plants can do," said Johanna Schmitt, a plant geneticist at Brown University in Providence, R.I.

Plants have to do clever things since they're stuck in place and must find ways to cope with enemies and hard times. "They can't just walk away," said Leslie Sieburth, a researcher at the University of Utah in Salt Lake City.

To compensate for their immobility, plants have genes strung along long threads of DNA that direct them to perform some remarkable feats. Though plant behavior may seem obvious to farmers and gardeners, it's only recently that biologists are learning exactly how they work, down at the level of individual genes and molecules.

Researchers have identified genes that help plants recognize when days are growing longer or shorter. Other genes force a plant to sit through a cold winter before allowing it to blossom. Another maintains a 24-hour internal clock. Some genes help plants "remember" the experiences of their "parents," the plants whose seeds gave them birth, Schmitt said.

Plants use color and smell to lure insects that spread their pollen or to repel hungry predators. Plants aren't above using dirty tricks, such as attracting wasps to lay their eggs inside caterpillar larvae so the caterpillars won't grow up to eat them.

Some plants can solve math and logic problems of a sort. They calculate the ratio of two different hues of red light to decide when there's too much shade and they need to grow taller. When roots sense that water is short, a gene called BYPASS1 sends a signal to the stem telling it to produce fewer, smaller leaves.

"This is a logical response to drought, because leaves are the major place where water is lost," Sieburth said.

Of course, plant talents are a far cry from animal — not to mention human — mental powers. Plants don't have a brain or central nervous system. They don't have language, emotions, fall in love or suffer the pangs of guilt.

Researchers expect their work will have practical value for farmers and home gardeners.

Judith Roe, a plant geneticist at Kansas State University in Manhattan, said understanding how plants synchronize their flowering with the state of the environment will help researchers predict and manage the effect of climate change on future crops.

"Ongoing climate change is already influencing flowering time in many plants," Schmitt said. "Many British wildflowers are now blooming earlier than they did 50 years ago."

"In flowering plants, the time of flowering is probably the most critical period in their life cycle," Roe said. "At this point, they are particularly vulnerable to environmental stresses."

To figure out how plant genes work, the National Science Foundation this fall awarded a $5 million research grant to an international team of scientists headed by Schmitt. Their task is to identify the molecular mechanisms by which plants know when to grow and when to flower — two distinct stages of vegetable life that must be kept apart.

A gene called FRIGIDA, for example, prevents plants from flowering prematurely, before winter has passed. "If the gene is faulty, it may flower too soon," Schmitt said.

"Successful reproduction and the development of seeds and fruits depend on flowering at the right time," said Jo Putterill, a biologist at the University of Auckland, New Zealand.

To make smart choices, plant genes must take in multiple cues from their environment — light, temperature, moisture, gravity, etc. — and assemble them into a meaningful whole. That's a rudimentary version of the way an animal's brain integrates various signals from its eyes, ears, fingers and stomachs.

The messages that tell a plant it's time to blossom turn on several series of genes, called "pathways," which lead to other master genes controlling the roots, stems and leaves.

"The balance of signals from these pathways is integrated by a common set of genes to determine when flowering occurs," Putterill said.

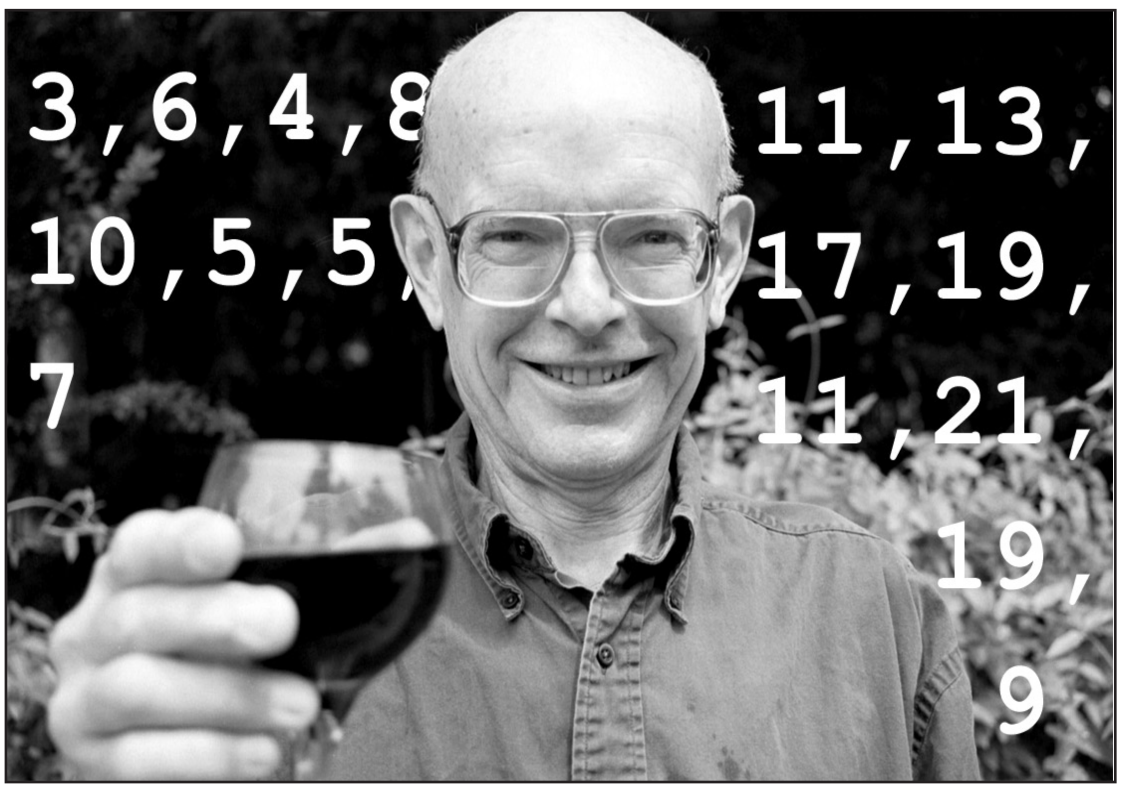
NASA is also interested in plant genetics. The space agency is financing research at North Carolina State University in Raleigh to study how plants will respond to changes in mechanical force and gravity on a spaceship, the moon or Mars. Researchers have identified 64 genes that respond to gravity, according to Heike Winter Sederoff, a botanist at N.C. State.

"When a plant is blown by the wind, flipped over or its roots are disturbed by an animal, specific genes responsible for keeping the plant stable" and roots growing respond very quickly, often within one minute of the disturbance, Sederoff reported.

Schmitt said scientists still don't understand how plants accomplish many of their clever tricks. "There are huge unanswered questions," she said. "That's what the National Science Foundation project is all about."

Mathematician reaches 100k milestone for online integer archive

BY ALONSO DEL ARTE
Contributing Writer



Photoillustration by Alonso del Arte/The South End

Neil Sloane toasts with a glass of wine the addition of the 100,000th sequence to his Online Encyclopedia of Integer Sequences in an "e-party." The original picture was taken by his wife, Susanna Cuyler.

Mathematician Neil Sloane drives a 1987 Honda Prelude with more than 100,000 miles on it. He has something else that has crossed the 100,000 milestone: the Online Encyclopedia of Integer Sequences.

Sloane added the 100,000 sequence Monday.

The database catalogs sequences of integers for the benefit of mathematicians, scientists and anyone interested in mathematics.

The 100,000 sequence is also of interest to archeologists.

It is: 3, 6, 4, 8, 10, 5, 5, 7, which are the numbers that were found on the middle column of a 22,000-year-old bone in the Congo. The left column read 11, 13, 17, 19, which is a prime quadruplet, and the right column read 11, 21, 19, 9. There are sequences in the OEIS that relate to physics — such as the centered cube numbers that relate to shells of atoms — biology and even music (such as 2, 2, 4, 4, 2, 6, 6, 2, 8, 8, 16, which is in the lyrics of an Argentine children's song).

The OEIS works like a search engine. In the search box, one can enter a few terms of the sequence separated by either commas or spaces, for example, "5, 7, 11, 23, 47," and it answers with all sequences it finds with those numbers, such as safe primes for the Diffie-Hellman data encryption algorithm in the example above.

One can also use word search to look up the numbers by name, such as "Motzkin numbers," and it replies with the sequence 1, 1, 2, 4, 9, 21, 51, 127, etc.

In addition to as much as four lines of numbers for each sequence found, the database also replies with information on the sequence, such as relevant research papers and interesting comments. For example, someone researching centered triangular numbers might learn that adding up the first n centered triangular numbers gives the answer to an n-tall magic square.

Sloane started rounding up integer sequences in the 1960s, entering them on punch cards, when he was working on neural networks as a graduate student at Cornell University.

Many University of Michigan professors tell their students about this resource, and putting in a word search at the OEIS for "umich.edu" yields about 80 results, while a word search for "wayne.edu" turns up none. Anyone who spots an interesting sequence that's not already in the database can send it in and get credit for it.

Although Sloane acknowledges that all the "core" sequences — such as the prime numbers, Catalan numbers, and the Fibonacci sequence — are already in the database, he believes the OEIS has an infinite potential for expansion.

"The world of science is continually expanding, and new problems arise every day, and produce new sequences," Sloane said.

Professor Lawrence Brenton, who headed the WSU Undergraduate Research Group, hearing about the OEIS for the first time yesterday, looked up the sequence "2, 3, 7, 43, 1807." These relate to Znám's problem, on which Brenton worked on in 1999 with Ana Vasiliu, an undergraduate student at Wayne State University at the time.

They published a paper together listing all the possible solutions to this problem when one of the variables is set to 8, for which there are 93 solutions. While the OEIS does not mention Brenton or Vasiliu, it does have a link to the Mathworld page on Znám's problem, which credits them with their discovery of the 93 solutions for Z(k) = 8.

"This is a neat idea," said Brenton of the OEIS. "This is the sort of thing that used to be put in book form." Brenton reminisced about the time he spotted a mistake in Paulo Ribemboim's "Book of Prime Number Records." He sent Ribemboim a letter with a correction, but Ribemboim had retired from the book writing business.

Sloane has published a couple of books of integer sequences, but the OEIS has the advantage of being updated on a more frequent basis.

And while the OEIS, which is accessed through a Web browser-like Internet Explorer, is much faster than the punch cards Sloane originally stored the sequences in, Brenton was disappointed by the speed of the OEIS search engine when he entered the sequence "2, 3, 5, 7." It's not as fast as Google, but Brenton said he was fascinated enough to look up a few more sequences on it.

The Encyclopedia of Integer Sequences is available online at:

http://www.research.att.com/~njas/sequences/index.html