with too much sinigrin will leave and chew on the plant's neighbor. Aphids aren't much bothered by sinigrin, so when choosing between two plants in the mustard family, they attack the larger one. Aphids therefore eliminate the benefit of slug protection, making sinigrin production potentially wasteful. —S. MILIUS

Snappy Transition

Venus flytrap inspires new materials

Inspired by the quick-shut action of the Venus flytrap, researchers have designed a material patterned with microscale hills that can rapidly flip to form valleys. Such materials could serve as fast-release adhesives, sensors in food packaging that detect spoilage, and quick-change lenses.

To capture its prey, the Venus flytrap takes advantage of a snap instability that resembles half a tennis ball flipping inside out. Uneven stresses in the outer and inner cells of the plant's leaf make it move quickly without muscles (*SN: 1/29/05, p. 69*).

To build snapping surfaces, Alfred Crosby and Douglas Holmes of the University of Massachusetts, Amherst, molded a silicone polymer into a flexible layer, 1.5 millimeters thick, with circular indentations. They stretched this layer, and then bonded another layer of the same polymer over it, creating an array of enclosed pockets. When the double-layered material contracts, the second layer wrinkles to form a pattern of convex microlenses a few hundred micrometers across or less—roughly the diameter of a human hair.

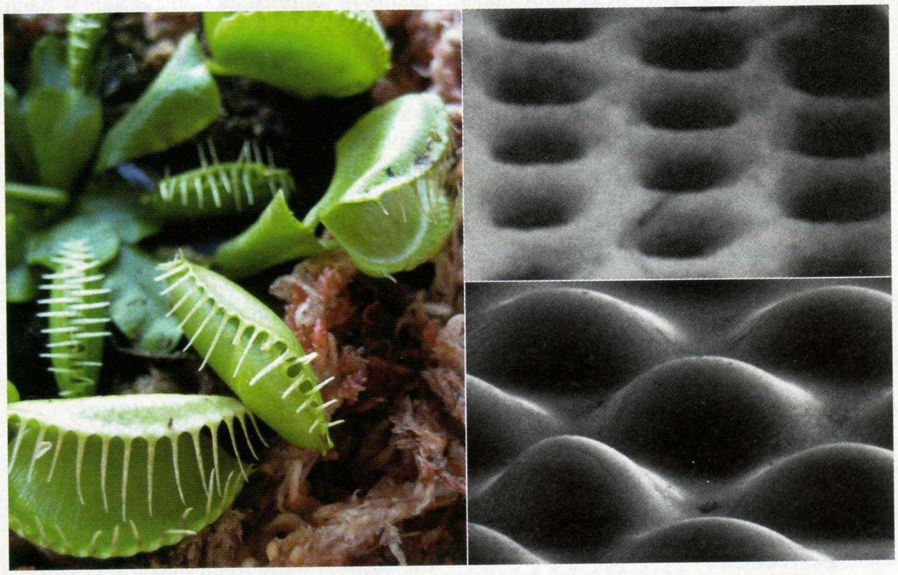
External cues can change the surface geometry within tens of milliseconds, the researchers showed. Mechanical pressure can flip the lenses from convex to concave reversibly or permanently. Chemicals can also trigger the snap instability. When the researchers treated silicon in the polymer's surface with oxygen, the resulting chemical reaction stressed the surface, causing the pockets to flip from convex to concave. Adding fluids that swelled the polymer popped concave surfaces back into convex ones.

Similar surfaces could also respond to heat, light, or electricity, Crosby says, but the primary innovation is that there's a fast mechanical response without added energy. The key feature of a snap instability, he says, is that "there are very, very large changes in shape and geometry with a very, very small amount of pressure. So it's extremely sensitive." The researchers report their findings in the November *Advanced Materials.*

"Learning from nature can actually teach us how to come up with something more functional," says Hongrui Jiang of the University of Wisconsin–Madison.

Incorporated into food packaging, such surfaces could work as sensors that could reveal a hidden warning in response to chemical spoilage or temperatures above a set threshold, Crosby says. In addition, small biodegradable chips with these pockets could transport drugs in the bloodstream, snapping open when they reached their targets.

The researchers expect to make surfaces larger than the square centimeter or so they've created so far. And they're already working to make their enclosed quick-change pockets smaller, from 100 nanometers to 500 nm across. Varying the pockets' size and spacing will allow scientists to control the physics of the response, tune the sensitivity of the sensors, and minimize inappropriate responses. —S. WEBB



FLIP-FLOP **In the same way that leaves of Venus flytraps (left) can quickly snap shut, depressions in the surface of a new material (top) can flip into bumps (bottom).**

HOLMES AND CROSBY

Einstein Unruffled

Relativity passes stringent new tests

By tracking the moon's location to within 1 centimeter, astronomers have put general relativity, Albert Einstein's theory of gravity, to a stringent new test. The theory stood up. In a separate experiment, physicists reconfirmed Einstein's older predictions on the stretching of time.

While both general relativity and quantum theory so far fit experimental data very well, their incompatibility makes physicists believe that at small scales either one of them or both must be wrong. Scientists constantly work to improve the sensitivity of their experiments to violations that might point to a new "theory of everything."

Astronomers at the Harvard-Smithsonian Center for Astrophysics in Cambridge, Mass., have now performed a new analysis of 35 years' worth of data on the moon's distance from Earth, including data they recently collected themselves with centimeter precision. The data tracked the time it took for a laser beam to reach a mirror on the lunar surface—left behind by the Apollo 11 astronauts—and bounce back to Earth. The results, described in an upcoming *Physical Review Letters*, confirmed one of general relativity's cornerstones: The laws of gravity are the same in all frames of reference.

The results place some strict requirements on any conceivable theory of everything, says team member James Battat.

Last year theorists Alan Kostelecký and Quentin Bailey of Indiana University in Bloomington, calculated the implications for gravity of a broader theory developed by Kostelecký. Called the standard-model extension, it represents the most general form that a theory of everything must have to fit the best known data. It involves more than 200 parameters—like so many knobs physicists can turn to change the equations underlying general relativity and quantum theory.

For example, some of the knobs would change Einstein's equations, Kostelecký says. "You don't have $E = mc^2$ anymore," he says as an example. "You have $E = mc^2$ plus a little bit"—a large number of tiny, hypo-