Biology

Acid explanation of Venus flytrap spring

Ever since the Venus flytrap was first described in 1763, then called "the great wonder of the vegetable world," biologists have puzzled over the mechanism by which an insect touching the specialized leaf triggers the sudden closing of the jaw-like lobes. Now Stephen E. Williams and Alan B. Bennett report that movement of hydrogen ions and subsequent cell expansion underlie the rapid springing of the plant trap.

The two lobes that form the trap are attached so they resemble an empty clam shell, held open like a hunter's spring trap. In the center of each lobe, on the surface inside the trap, there are a few bristle-like trigger hairs. Williams and Bennett report in the Dec. 10 SCIENCE that when these trigger hairs are touched, the cells in the outer layers of the lobes expand almost instantly, causing the trap to close. "This rapid cell expansion is possibly the fastest on record in the plant world," Williams says. The cell expansion is irreversible; the trap reopens only when cells of the inner layers expand to match the outer layer's growth.

The cause of the outer layer cells' rapid expansion is acidification of the cell walls, the researchers report. When an insect brushes against the trigger hairs, they produce electrical pulses similar to those of animal nerve cells. The pulses cause a cellular pump to move hydrogen ions out of the plant cells. Because there is already a higher concentration of hydrogen ions in solution outside the cell than inside, this process requires large amounts of energy. Williams and Bennett measure consumption of 29 percent of the energy-storing ATP molecules from the trap lobes during the 1 to 3 seconds required for trap closure.

In their recent experiments Williams, of Lebanon Valley College in Annville, Pa., and Bennett, of Cornell University in Ithaca, N.Y., demonstrated that making the cell walls acidic with an applied acid solution can induce cell expansion and trap closure. On the other hand, providing the cells with a buffer that prevents acidification prevents closure of the trap. The scientists suggest that the Venus flytrap can be a useful system for studying chemical and structural changes of plant growth.

Maternal behavior without birth

Hormones have been used in a variety of experiments to trigger maternal behavior in female animals that have not just given birth. But no combination of hormones has produced the full array of behaviors that appear so rapidly and reliably in the mother after a baby animal is born. Scientists in England, France and Australia report in the Jan. 7 SCIENCE that adding a sensory cue to hormone treatment can produce the full complement of maternal behavior in ewes. Five minutes of vaginal stimulation, either with a vibrator or a rubber bladder, makes ewes accept a newborn, unrelated lamb, licking it and emitting low-pitched bleats and becoming agitated when the lamb is removed. The stimulation can also make a ewe that has recently given birth adopt an alien newborn lamb; the ewe may even lick the newborn alien more than her own slightly older offspring. Among ewes whose own lambs had been removed two hours after birth, after a selective bond had developed, vaginal stimulation could induce the ewes to accept an alien newborn without the usual aggressive and disturbed behavior.

E.B. Keverne of the University of Cambridge in England, F. Levy and P. Poindron of the Institut National de la Recherche Agronomique de Nouzilly in France and D.R. Lindsay of the University of Western Australia conclude, "In addition to the obvious application of these findings to animal husbandry, these studies illustrate the importance of vaginal stimulation for maternal behavior in hormonally primed ewes." Relating their result to reports of rodent behavior, the scientists speculate that vaginal stimulation in sheep may cause internal release of the hormone oxytocin and in addition may activate an olfactory mechanism crucial to mother-infant bonding.

Technology

Sticky Teflon for diamond wheels

Many consumers are familiar with nonstick frying pans that are coated with Teflon, a carbon-fluorine compound. Substances as diverse as eggs and oil fail to wet or adhere to such Teflon-coated surfaces. However, in "an amazing irony," a physical chemist at the Los Alamos National Laboratory has used Teflon, in the form of a fluorocarbon resin, as a kind of glue to bond diamonds to metal. The result is a highly durable material suitable for manufacture into superior grinding wheels useful in machining operations.

The starting material is "diamond grit," which looks like fine sand. Under a microscope, these artificially produced diamonds look like an assortment of little arrowheads. When these diamonds are placed in a sulfur hexafluoride plasma (a highly ionized gas), fluorine atoms attack the diamond surfaces to produce, essentially, thin Teflon coatings. These fluorinated diamonds are mixed with a Teflon emulsion to produce a paste, which is then dried. The resulting powder is poured onto a soft aluminum cylinder. Applying a pressure of 20,000 pounds per square inch at 325°C causes the Teflon to melt and form a chemical bond between the aluminum surface and the diamonds. The pressure also grinds the diamonds into the aluminum surface, while the heat treatment hardens the aluminum. The result is a tough diamond wheel that can spin up to 17,000 rotations per minute and can cut easily into ceramics and metals like steel.

Gene W. Taylor, who made the discovery, says the patented process is an outgrowth of explosives bonding technology. His process appears to pack a greater mass of diamonds into a given volume than other methods. He speculates that his process may also reduce the cost of making odd-shaped diamond tools for specialized applications. Even the jewelry industry may be interested if it turns out that diamonds can also be bonded to metals like gold or platinum, he says.

Thermal power from sunlight & 'smoke'

A Lawrence Berkeley Laboratory physicist, Arlon Hunt, has designed and built a novel solar receiver that heats gases to high temperatures while the device's walls remain much cooler. Recent tests at a Georgia Institute of Technology solar facility demonstrated that a prototype receiver produced 30 kilowatts of thermal power, and that with minor modifications it could generate 300 kilowatts, enough to supply a small community.

The stainless steel and aluminum receiver, called SPHER (for Small Particle Heat Exchange Receiver), stands 5 feet high and measures 4 feet in diameter. Concentrated sunlight, from a field of mirrors or a parabolic reflector, shines into the bottom of the receiver through an 8-inch-diameter window. Air containing a low concentration of carbon particles enters the receiver and swirls downward toward the window. The fine, smoke-like carbon particles quickly absorb sunlight and transfer their energy to the gas molecules, heating the gas very effectively. When the air temperature gets high enough, the carbon particles oxidize to produce carbon dioxide. With appropriately sized carbon particles, temperatures in the receiver can reach anywhere between 500°C and 1,000°C. Very little sunlight penetrates the carbon suspension to strike the inner walls, so the walls need not be made from special high-temperature-resistant materials.

SPHER has several advantages as a solar energy system. "It is highly efficient, it is simple in design and light in weight," says Hunt. The hot gases exiting the receiver can power a gas turbine that supplies mechanical or electrical energy. Hunt says larger solar receivers of this type would need only 5 kilograms of carbon per hour to operate a 10-megawatt turbine, which could supply electrical power to 10,000 homes. The system also works with other particle-gas combinations. "One of the most exciting future applications," Hunt says, "is to run high-temperature chemical reactions, powered by sunlight."