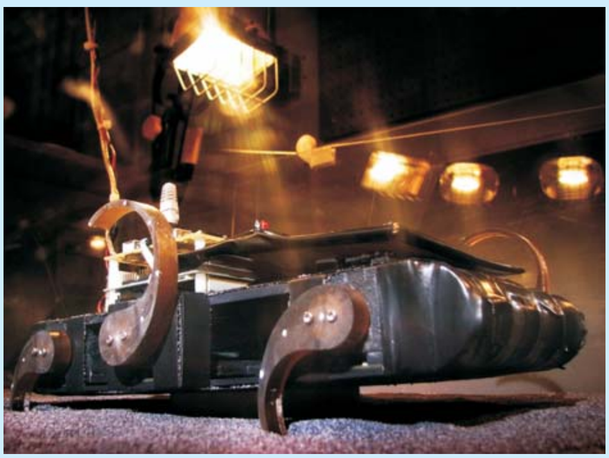
installed arrays of sensors in the large—2-cm-wide, 1-m-deep—crack in the foreground of the photograph: Temperature and relative-humidity data were acquired every 10 minutes for more than two years. Every day, the Sun's warmth propagates slowly down through the rock until, as the evening cools, the air in the crack becomes less dense than the overlying atmosphere, and convection sets in. Venting of warm, moist air from the rock surrounding the crack, along with the entrainment of cool dry atmospheric air, then continues until dawn. Convection takes place for up to 19 hours a day in the winter, 12 during the summer. The process, say the researchers, is natural and pervasive and could have a large impact on Earth-atmosphere gas exchange. Also, because water vapor, carbon dioxide, and other gases are involved, there may be implications for climate change studies. (N. Weisbrod et al., *Geophys. Res. Lett.* **36**, L02401, 2009, doi:10.1029/2008GLO36096.) —SGB

A robot walks, sinks, and swims in granular media. Inspired by crabs, cockroaches, and other nimble creatures, engineers at the University of Pennsylvania have designed robotic vehicles to traverse complex terrain such as deserts and presumably the Martian landscape. Equipped with six spring-loaded and synchronously rotating C-shaped limbs, the robots outmaneuver



current military and rescue vehicles over coarse but rigid terrain. On granular media, however, that agility comes at a cost: The latest robot model, the 30-cm-long SandBot, shown in the image and designed by Georgia Institute of Technology physicists in collaboration with the UPenn engineers, drops from a speed of 60 cm/s on a rigid surface to a crawl of 2 cm/s in a bed of poppy seeds. (See videos with this item at http://www.physicstoday.org.) Only when the researchers empirically tweak the limb-control parameters does the speed approach a respectable 30 cm/s. A team led by Daniel Goldman at Georgia Tech set out to determine how the robot's speed is influenced by the angular frequency of its limbs and the granular medium's packing fraction. The experiments revealed that the robot's legs sink into the fluid-like medium, then slip, before walking forward. Below a critical packing fraction, and at high limb frequencies, a sharp transition from rotary walking to a slower swimming motion was observed. The researchers say that understanding the physics associated with crater formation and collapse in granular media will lead to advances in limb geometry and robot locomotion. (C. Li et al., *Proc. Nat. Acad. Sci. USA* **106**, 3029, 2009.) —JNAM

Carbon nanotubes for fuel cells. The several approaches being pursued for fuel cells vary in their chemical reactions, materials, and optimal operating conditions, but they share a basic configuration (see PHYSICS TODAY, November 1994, page 54, and October 2006, page 38). A fuel, often hydrogen, is oxidized at the anode, where it liberates electrons. The electrons travel through and power an external circuit and eventually reach the cathode, where oxygen is reduced. Meanwhile, to complete the redox reaction, ions travel through an electrolyte that separates the electrodes. In alkaline fuel cells, first developed for the Apollo space missions in the 1960s, oxygen combines with water and electrons at the cathode to form hydroxyl ions (OH^-) that travel through an aqueous alkaline electrolyte to produce water by combining with protons from the anode. Commercialization of those fuel cells, however, has been limited by the high cost of the platinum used for the cathode. New work by Liming Dai of the University of Dayton and colleagues at the Air Force Research Laboratory and the University of Akron has shown that vertically aligned carbon nanotubes doped with nitrogen provide an efficient, lower-cost alternative for the cathode. Nitrogen-doped nanotubes have better long-term stability and, unlike Pt, are not harmed by the presence of carbon monoxide or any fuel molecules that cross the electrolyte from the anode to the cathode. The researchers attribute the catalytic performance to the relatively high positive charge density on the carbon atoms adjacent to the nitrogen atoms. (K. Gong et al., *Science* **323**, 760, 2009.) —RJF

Martian methane. A group of astronomers headed by Michael Mumma of NASA's Goddard Space Flight Center in Greenbelt, Maryland, has reported in substantial spatial and temporal detail the first definitive detection of methane (CH_4) in the atmosphere of Mars. The Martian atmosphere consists overwhelmingly of oxidized gases such as carbon dioxide; reduced gases such as methane were known to be rare. In 2003 and 2006, using two telescopes on Mauna Kea in Hawaii, the group observed much of the planet's surface spectroscopically at IR wavelengths to confirm the presence of methane and determine its seasonal and "ariegraphic" distribution. (A Martian season is about six months long.) Mumma and company found extended plumes of methane that appear to emanate at substantial rates from three localized sources in the northern summer (see the figure). They suggest that the summer emergence results from the unfreezing of pores and fissures connecting with underground accumulations of the gas, and that oxidation in winter dust storms accounts for the very meager methane signal remaining at the start of spring. Is the methane biogenic? On Earth 90% of it is, the rest coming from inorganic geochemistry. If it is biogenic on Mars, it could be a vestige of life long extinct or a sign of ongoing life in warm precincts deep underground, perhaps energized by molecular hydrogen from the hydrolysis of water by radioactivity. Isotopic ratios measured by future IR missions to Mars should help determine the methane's origin. (M. J. Mumma et al., *Science Express* **323**, 1041, 2009, doi:10.1126/science .1165243.) —BMS