physics update

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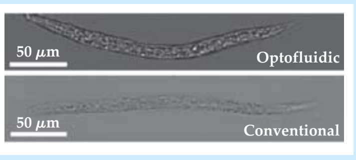
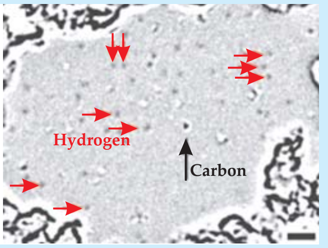
The Montreal Protocol mitigates climate change. Since 1 January 1989, the signatories of the Montreal Protocol have curbed their production and consumption of $CFCl_3$, CF_2Cl_2, and other ozone-depleting substances (ODS). The Antarctic ozone hole continues to form every year and let harmful radiation reach the surface. In some years, ozone levels also drop alarmingly in the Arctic. Even so, observations suggest Earth's beleaguered ozone layer is beginning to recover. According to a new study, the protocol is also providing the polar regions with some protection from another threat: climate change. Olaf Morgenstern of Cambridge University and his colleagues have simulated what Earth's climate would be like in 2025 if levels of ODS had continued to rise unchecked since 1989. Ozone depletion affects circulation and climate in the stratosphere and, through coupling, in the atmosphere closer to Earth's surface. The Cambridge model predicts an annual mean warming of around 1 K in the polar regions and a remarkable springtime warming of 2–3 K in the lee of the Antarctic Peninsula. In the Arctic, Canada and Greenland warm considerably more than northern Siberia. The predicted high-latitude patterns resemble observed temperature trends, suggesting a depleted ozone layer could modulate climate change. Morgenstern and his colleagues conclude, "The Montreal Protocol has provided an enormous benefit not only to the stability of the stratospheric ozone layer but also to surface climate." (O. Morgenstern et al., *Geophys. Res. Lett.*, in press.) —CD

Lensless, microfluidic imaging of cells and tiny worms. In scanning microscopy, images are put together by sweeping a single narrow beam back and forth over a sample. If you had a wide array of multiple beams, one scan would suffice. And if the sample moved over the array, you wouldn't need to scan at all. That idea is behind a new optofluidic imaging scheme developed for biological applications by Caltech's Changhuei Yang and his colleagues. At the heart of the scheme is an off-the-shelf sensor whose CMOS pixels are read out individually. Contrast is achieved when a sample, under constant illumination, momentarily shadows the pixels as it passes over them in a microfluidic channel. At $10 \times 10\ \mu m^2$, the pixel size is too big to resolve the parts of amoebae and other tiny organisms. To boost the resolution, Yang masks the pixels with a commensurate array of 1-μm-diameter holes. Although 99% of the sensor is masked, 100% of a sample is imaged because the sample's path over the lines of holes is canted at a slight angle. Thanks to the angle, an organism or cell is scanned not only along but also across its whole body. The Caltech team built and demonstrated two types of imager; they differ in how they stabilize a sample's orientation during a scan. In one type, suitable for imaging tiny worms and other elongated samples, gravity pulls the samples. Confinement suffices to prevent the samples from tumbling. In the other type, suitable for squatter, more rounded samples, pressure pushes the samples. Tumbling is forestalled by a strong DC electric field, which polarizes and aligns the samples. Both imagers are barely bigger than a US quarter and, as the accompanying images show, provide resolution comparable to that of a conventional optical microscope. (X. Cui et al., *Proc. Natl. Acad. Sci. USA* **105**, 10670, 2008.) —CD



Imaging light atoms on graphene. Graphene makes a nearly ideal substrate for transmission electron microscopy (TEM). Composed of a honeycomb carbon lattice just one atom thick, it is the thinnest, most transparent support possible for adsorbed atoms and molecules. But it's also strong and conductive, able to trap the atoms long enough for good images to be captured and yet suffer minimal charging effects from the electron beam. Researchers from the University of California, Berkeley, and Lawrence Berkeley National Laboratory have taken advantage of those properties to reveal individual hydrogen and carbon adatoms that appear as if suspended in free space. In order to enhance the signal-to-noise ratio, the team summed multiple scans. As pictured here, carbon (black) and hydrogen (gray) adatoms show up as dark spots on a bright background, and atomic vacancies created from electron irradiation appear as white spots. The visualization of the low-contrast light atoms allowed the team to follow the dynamics of individual adsorbed atoms and organic molecules in real time for several minutes. The demonstration presents a straightforward way of using TEM to study both atomic-scale chemical diffusion and reactions that occur under electron irradiation. (J. C. Meyer, C. O. Girit, M. F. Crommie, A. Zettl, *Nature* **454**, 319, 2008.) —RMW



Optical vortex coronagraph demonstrated. One difficulty with finding extrasolar planets is that a planet's light is overwhelmed by that of its parent star. To block that light, astronomers typically occult the star with a disk in an instrument called a coronagraph. At the University of Arizona, however, Grover Swartzlander's group has developed another method: They focus the primary star onto the very center of a so-called optical vortex lens, which acts like a helical phase mask, and the on-axis source of light is removed from the optical path while the off-axis source of light passes through. Shown here is the central region of a 2-mm square OVL. The instrumentalists put the OVL into a coronagraph, incorporated some adaptive optics to eliminate the twinkling caused by atmospheric turbulence, and mounted the entire package on an 8-inch telescope that they pointed at the binary star system Cor Caroli in the constellation Canes Venatici. Without the optical vortex coronagraph, only the primary star, with its 12-fold more light flux than the secondary, could be seen. With the OVL in place, the secondary star became visible. The primary's light was suppressed by 97%, but not over that star's entire disk because the optics were not optimally aligned. Next on the researchers' agenda is to fabricate higher-quality OVLs and more advanced adaptive-optics and optomechanical alignment systems. (G. A. Swartzlander et al., *Opt. Express* **16**, 10200, 2008.) —SGB