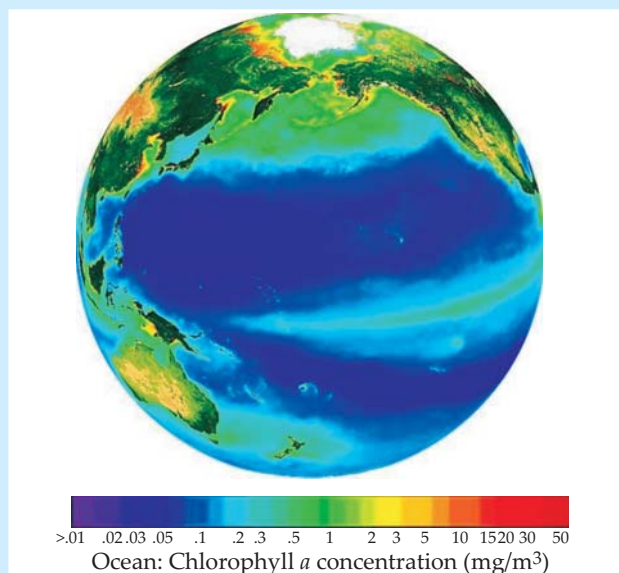


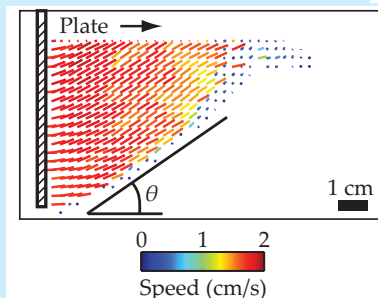
tic weather phenomena known in the Atlantic region as hurricanes and in the Pacific as typhoons or tropical cyclones (see the Quick Study on hurricane formation by Kerry Emanuel in *PHYSICS TODAY*, August 2006, page 74). A new model from a research collaboration led by Anand Gnanadesikan at the National Oceanic and Atmospheric Administration's Geophysical Fluid Dynamics Laboratory in Princeton, New Jersey, shows how strongly correlated the sea surface temperature (SST) is to the ocean's color. The image depicts average concentrations (in mg/m^3) of chlorophyll—the green pigment in phytoplankton—from 1997 to 2000 in the Pacific Ocean, where more than half of the reported typhoon-force winds (greater than 32 m/s) occur. Considering an extreme scenario, the researchers set the concentration of chlorophyll to zero and then studied the evolution of cyclones in the North Pacific Ocean. Without chlorophyll to absorb much of the solar radiation, SSTs drop. Air over the colder water sinks, dry-



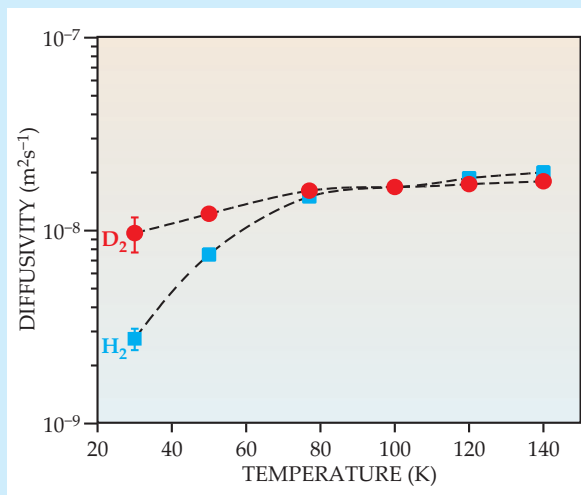
ing the atmosphere and increasing wind shear, which quenches typhoon formation. Although typhoon frequency increased by 20% along the equator in that scenario, the simulation predicted an overall drop in the region—up to 70% for areas beyond 15 degrees north of the equator—and a decrease in frequency of the most intense cyclones. (A. Gnanadesikan et al., *Geophys. Res. Lett.*, in press.) —JNAM

Plowing through a granular medium. Children frolicking in a sandbox probably don't think about the drag forces exerted on their limbs as they displace grains of sand. But physicists Nick Gravish and Daniel Goldman (Georgia Tech) and Paul Umbanhowar (Northwestern University) do think about such forces. Now they have conducted a systematic study of how the drag force on a vertical plate partially submerged in sand-sized glass beads depends on the beads' packing fraction ϕ . Their study reveals a surprising phenomenon: For a dense packing—that is, when ϕ exceeds a critical value ϕ_c —the drag force oscillates as the plate moves horizontally. The crucial physics, argue the authors, hinges on the phenomenon of dilatancy: densely packed beads can become less dense when sheared. Dragging a plate through a dense packing creates a "shear plane" that runs from the bottom edge of the plate to the surface of the beads and makes an angle θ with the horizontal. Particles near the shear plane tend to move parallel to it, toward the surface; particles beyond the plane hardly move at all (see the figure). Shear

forces arising at the plane cause the local packing fraction to decrease, which makes it easier to move the plate. When the packing fraction dips to ϕ_c , the shear plane remains stationary at the surface even as its bottom edge moves with the plate; thus θ increases, which causes the drag force to also increase. Once the drag force is high enough, a new low- θ , high- ϕ shear plane forms, and the cycle repeats. Sandboxes, it seems, have pleasures to offer physicists and children alike. (N. Gravish, P. B. Umbanhowar, D. I. Goldman, *Phys. Rev. Lett.*, in press.) —SKB



Quantum effects turn pore diffusion on its head. Separating isotopes is difficult business: Because an element's various isotopes share similar size and shape, separation methods such as thermal diffusion and centrifugation tend to be time and energy intensive. Now, however, a team led by Suresh Bhatia (University of Queensland, Australia) has shed new light on what may prove an attractive alternative—nanoporous materials known as molecular sieves. Normally, molecular sieves aren't particularly effective isotope separators. Take diatomic hydrogen and its isotopic relative deuterium. As one would expect, the lighter H_2 molecules diffuse through the porous molecular sieve faster than the heavier D_2 , but the difference is slight. That picture changes, though, if the temperature is low enough—and the pores small enough—for quantum effects to set in. If the pore size is on the order of the molecules' de Broglie wavelength, the molecules' zero-point energy becomes the important barrier for pore diffusion and small mass becomes a disadvantage. Not only does D_2 then diffuse faster than H_2 , it can do so by a substantial margin. Using quasi-elastic neutron scattering and carbon



molecular sieves with 3-Å-diameter pores, Bhatia and company directly measured those diffusivities, which differed by nearly an order of magnitude at the coldest temperatures. Although quantum sieve effects—first predicted nearly 15 years ago—had been previously seen in equilibrium adsorption experiments, the research team's findings represent the first microscopic observations of the kinetic phenomenon. (T. X. Nguyen, H. Jobic, S. K. Bhatia, *Phys. Rev. Lett.* **105**, 085901, 2010.) —AGS