who used a variant of the so-called naming game.[2] Artificial agents in a simulated population, beginning with no words for colors at all, were repeatedly tasked with describing different colors to one another. The individual agents independently invented words and categories and, based on the success or failure of their communications, adjusted their own categories and vocabularies to match those around them. (A communication was deemed successful if the word the speaker used appeared in the listener's vocabulary and allowed the listener to identify which of several randomly chosen hues the speaker meant.) Eventually, after some 500 000 repetitions for a 50-person population, they came to a near consensus, in which everyone in the same population categorized colors in almost the same way, but those categories could differ markedly between noninteracting populations.

The idea behind the naming game is not new: The philosopher Ludwig Wittgenstein wrote about the concept in the 1940s. But applying it to a continuous space, the visible spectrum, was an innovation. Curiously, the simulations—which accounted for none of the complexities of human societies or human vision—tended to stabilize at roughly 10–20 color categories, as shown in the figure, similar to the numbers found in real languages. But often those categories looked nothing like any human language.

Now, Baronchelli and colleagues have revised their model to include a real property of human vision, the just noticeable difference (JND; shown in the bottom panel), or wavelength resolution as a function of wavelength.[3] They ran a new set of computations in which their agents were not required to distinguish between colors that a real human couldn't tell apart. And they found that the categories that resulted from their JND-based simulations displayed exactly the same degree of clustering as the World Color Survey results did. The researchers hope that the quantitative agreement with empirical data will pave the way for greater use of synthetic modeling in studying language development and other areas of cognitive science. **Johanna Miller**

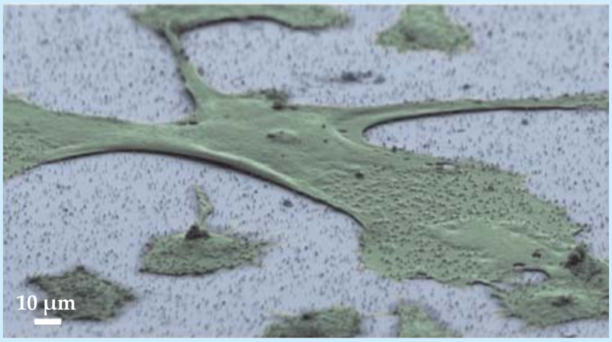
References

1. P. Kay, T. Regier, *Proc. Natl. Acad. Sci. USA* **100**, 9085 (2003).
2. A. Puglisi, A. Baronchelli, V. Loreto, *Proc. Natl. Acad. Sci. USA* **105**, 7936 (2008).
3. A. Baronchelli, T. Gong, A. Puglisi, V. Loreto, *Proc. Natl. Acad. Sci. USA* **107**, 2403 (2010).

physics update

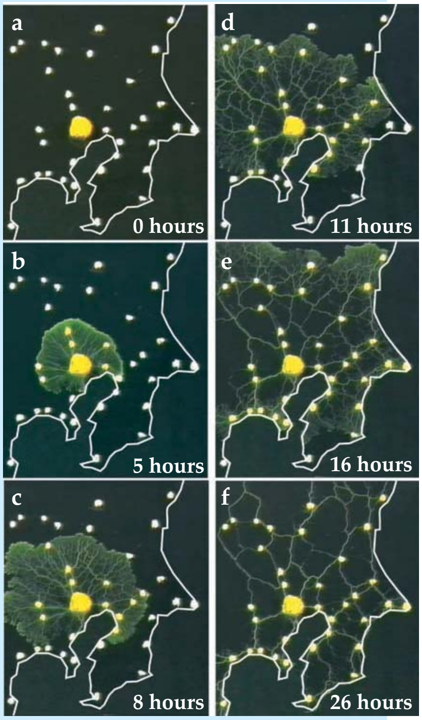
These items, with supplementary material, first appeared at http://www.physicstoday.org.

Nanowires transport biomolecular cargo. Biological and medical researchers have long sought to study or control cellular function by inserting biomolecular probes inside the cell. But those probes, which include peptides and nucleic acids, must first cross the cell's highly selective membrane. Traditional approaches to breaching that barrier are to chemically modify



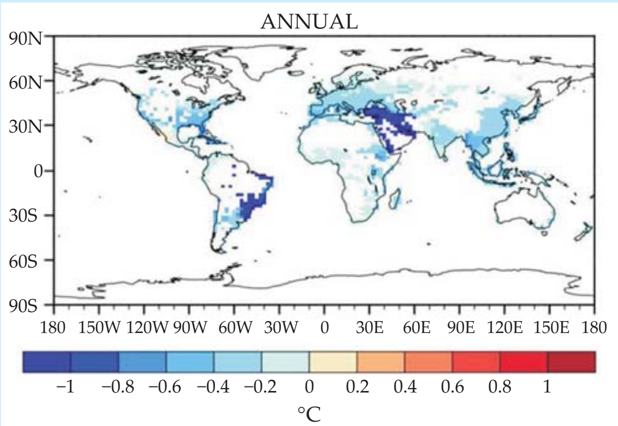
the probe or membrane and to pack the probe into a virus, which fuses to a cell's membrane before depositing its load; both methods induce unwanted side effects and are limited to delivering specific molecular cargo. Now a team of US and South Korean scientists, led by Harvard University's Hongkun Park, has developed a minimally invasive delivery method that exploits the ability of silicon nanowires to physically penetrate the cell's membrane. The researchers prepared vertically aligned nanowire arrays with a density of roughly 25 million nanowires/cm^2 and altered their surface chemistries to enable noncovalent binding of a broad spectrum of molecules. With the nanowire platform, they were able to simultaneously assay the intracellular effects of distinct molecular probes. In one experiment, the researchers layered human fibroblasts, shown green in the scanning electron microscope image, across the nanowires, shown in blue. Nearly all of the cells were impaled within one hour and received the bound probes within 24 hours. Impaled cells continued to grow for several weeks, albeit at a slightly slower rate. (A. K. Shalek et al., *Proc. Natl. Acad. Sci. USA* **107**, 1870, 2010.) —JNAM

Planes, trains, and slime molds. Designers of transportation networks have to weigh the cost of serving customers against the need for an efficient, robust system. Natural organisms, too, confront tasks in which they need to balance competing desiderata. As it forages for food, for example, a slime mold must balance cost (that is, the amount of protoplasm it extrudes), efficiency, and the ability to withstand injury. Remarkably, as recently reported by Atsushi Tero and colleagues from Japan and the UK, the molds do as well as transportation engineers in balancing their analogous competing needs. Panel a of the figure recreates a 17-cm-wide map of the principal cities served by the Tokyo railway system with a slime mold (yellow) at the location of Tokyo and food flakes (white) representing other cities. In about a day's time, the slime mold finds where the nourishment is and generates a protoplasm network with the food flakes as nodes. Standard metrics for analyzing transportation networks reveal that the mold's foraging network and the Tokyo railway system



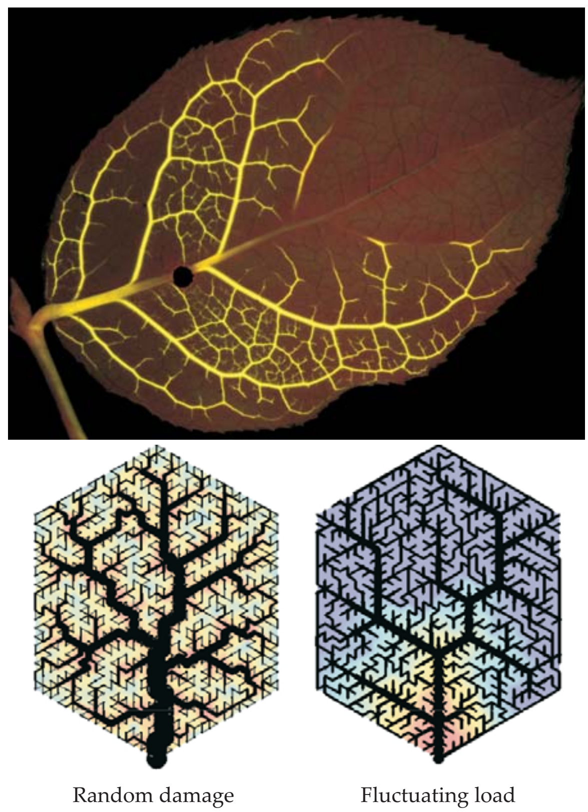
perform similarly. Perhaps more significantly, Tero and company imitated slime-mold networks in numerical simulations that don't incorporate detailed biochemistry. Instead, they include a feedback step in which tubular links carrying a large protoplasm flux grow wider and flux-poor links contract. By tweaking their simulation parameters, the researchers could nudge the network toward, for example, greater cost efficiency. With optimal parameters, they could even improve upon the work of slime molds and human engineers. (A. Tero et al., *Science* **237**, 439, 2010.) —SKB

White roofs, cool cities. Light-colored (high-albedo) surfaces reflect more sunlight than dark surfaces and therefore have a lower surface temperature and are surrounded by cooler air. The proposal that painting a building's roof white can save energy for the occupant has been around for more than a decade. In recent years, region-wide modeling of so-called urban heat islands has included albedo effects. Keith Oleson (National Center for Atmospheric Research, Boulder, Colorado) and his colleagues have now gone global. They started with a dataset of urban extent and urban properties in 33 regions of the world, and a sophisticated model that includes factors like building heights, street widths, and thermal and radiative properties of roofs, walls, and streets. Next, they imposed interior building temperature ranges consistent with climate and socioeconomic conditions. Finally, they coupled the model to a global climate model and varied the roofs' albedos. All grid cells in the final model contained rural regions and some also had urban areas. The figure shows the average annual difference in the heat island due to white roofs. (White cells on the map included no urban areas.) The heat-island effect



of cities is noticeably reduced. During the summer months, the use of air conditioning would also be reduced. Interestingly a closer look at data for the winter months showed a reversal at high latitudes, where the extra albedo effect prompts additional internal heating of buildings. (K. W. Oleson, G. B. Bonan, J. Feddema, *Geophys. Res. Lett.* **37**, L03701, 2010.) —SGB

Loopy leaf veins. Unlike the branches of a tree, the network of veins in a typical leaf is full of closed loops. Even after a visit by a hungry insect, no part of the leaf is cut off from the network, as shown in the top part of the figure. But is a leaf's fractal-like form, with loops of various sizes, the best possible network for resisting that type of damage, or might a different loop-filled structure be better? And is the hierarchical structure the optimum for any other criterion? Marcelo Magnasco (the Rockefeller University, New York) and colleagues sought to find out. Using a mathematical model that assigns each vein segment a cost proportional to its capacity raised to a power γ, they looked for the



networks with a given total cost that suffered the least average strain under two sets of circumstances. First, they looked at damage to a randomly chosen vein segment. Second, they considered the case of a fluctuating load, in which the amount of fluid to be delivered to each part of the network varied in time and space. (Real leaves do sometimes need to handle fluctuating loads. So, more obviously, do most human-built networks.) They found that for low values of γ (results for $\gamma = 0.1$ are shown in the figure), both cases yielded hierarchical networks of loops, qualitatively similar to real leaves. (E. Katifori, G. J. Szöllősi, M. O. Magnasco, *Phys. Rev. Lett.* **104**, 048704, 2010.) —JLM

A carbon halo. In most nuclei the protons and neutrons form a roughly spherical core of approximately uniform density. But along the edges—the so-called drip lines—of the chart of nuclides a handful of light nuclei have more nucleons than can be accommodated in the nuclear core. The excess, usually one or two neutrons, form a dilute distribution called a halo that extends far beyond the core. At the RIKEN Nishina Center for Accelerator-Based Science, a Japanese team has studied the reaction of heavy carbon nuclei with hydrogen and identified the extremely neutron-rich carbon-22, with its 6 protons and 16 neutrons, as a halo nucleus, the heaviest one yet found. Nuclear radii generally scale as the cube root of the total number of protons and neutrons, yet based on their cross-section data, the researchers calculated the radius of ^{22}C to be twice that of the much more common isotope ^{12}C; indeed, at 5.4 fm it exceeds the radius of lead-208. The halo of ^{22}C comprises two valence neutrons; determining their distribution and other aspects of the halo structure will require experiments with different target nuclei and different beam energies. (K. Tanaka et al., *Phys. Rev. Lett.* **104**, 062701, 2010.) —RJF