of both are low, wide lobes emerge instead.

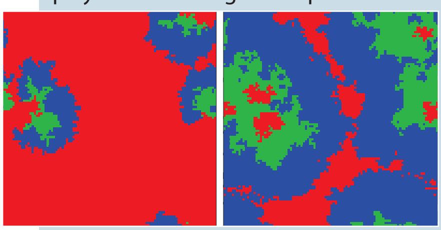
To explore a pattern common to 2D gardens—and discernable in some 3D ones—De Wit and her colleagues analyzed the growth kinetics of 173 curly-shaped precipitates they observed in several experiments (marked S_i in figure 1). The shapes, shown more clearly in the magnified view of S_3 in figure 2, were pervasive throughout a wide range of intermediate concentrations. And all of the curls conformed to the mathematics of a logarithmic spiral—the logarithmic dependence of angle on radius—the same structure found in natural systems such as seashells, snail shells, and the horns of animals. In the case of their experiments, De Wit says, "what matters is to have a solid that is pushed, breaks, and starts to rotate when material is added in a self-similar way at the end of a propagating tip."

Cartwright adds that so generic a model—independent of chemical details—is merely a first step to quantifying how the 2D system behaves. "We're hoping to model other features, such as the filaments, which are reminiscent of the stalks, or tubes, in 3D gardens, to further constrain the growth mechanism," he says. A detailed and quantitative 2D model would surely provide some insight and predictive power over the behavior of 3D gardens and such natural formations as deep-ocean hy-

physics update

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

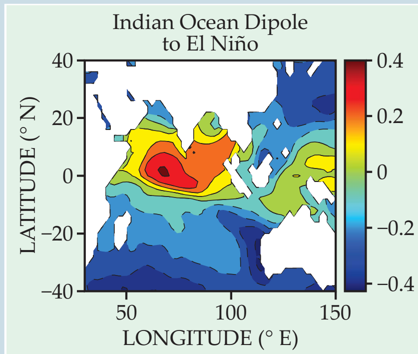
The cost and benefit of deception. Imagine the police arrest you and a colleague for some crime and offer individual deals if you will betray each other. If only one of you defects, that person goes free while the other, the cooperator, receives three years in prison. Mutual defection gets both of you a two-year sentence, and mutual cooperation results in a one-year sentence. That game theory scenario is called the prisoner's dilemma. Versions of it, often involving many players who adapt their strategies as they repeatedly play the game, have been used to study how cooperative behavior might evolve in a population of competing individuals. Now Attila Szolnoki of the Hungarian Academy of Sciences and Matjaž Perc of the University of Maribor in Slovenia and King Abdulaziz University in Saudi Arabia have introduced deception to the game. They ran Monte Carlo simulations with up to 3.6×10^7 players interacting on a square lattice. In addition to defectors, the simulations included conditional cooperators who defect if they detect a defecting opponent, and deceptive defectors who always avoid detection, though at



a cost. After playing against its four neighbors, a player could switch strategies depending on how well it did in comparison to the previous player; a randomly chosen neighbor then went next. The figure above shows snapshots from one simulation after 60 (left panel) and 100 (right panel) Monte Carlo steps; the population of cooperators (blue) grew at the expense of defectors (red), but in turn lost ground to deceptive defectors (green). The researchers found that such complex dynamics led to surprising evolutionary outcomes. For example, deception sometimes became more effective when its cost increased, and upping the likelihood of detection didn't always promote cooperation. (A. Szolnoki, M. Perc, *New J. Phys.* **16**, 113003, 2014.)

—SC

Quantitative causality. Cause and correlation are two different notions that are often confused. When phenomena *A* and *B* are causally related, their time evolutions are correlated. But correlation does not imply causality—an external agent such as an alarm clock, for example, can cause the correlated waking of two sleepers; the two isolated wakings, however, are not causally related. When the dynamics governing *A* and *B* are known, an information-theoretic notion called information flow rigorously determines the causal relations between *A* and *B*: If the information flow from *A* to *B* is zero, *A* has no effect on *B*; otherwise, *A* does affect *B*.



Now X. San Liang of the Nanjing University of Information Science and Technology in China has shown how to obtain the information flow, not from *a priori* known dynamics but from correlations in the time-series graphs that detail the evolutions of *A* and *B*. He applied his result to a problem of practical interest for climate scientists—the relation between El Niño and the Indian Ocean Dipole (IOD), an aperiodic oscillation in sea surface temperature. Liang used correlations between time series—of sea surface temperatures in the Indian Ocean and of an index, called Niño4, that measures the overall strength of El Niño—to calculate the information flow from the IOD to El Niño shown in the figure. For a large swath of the northern Indian Ocean, the sign of the information flow is positive, which, according to information theory, means the IOD causes El Niño to be less predictable. That unusual causal link, suggests Liang, may be the reason climate scientists only recently recognized an influence of the IOD on El Niño. (X. S. Liang, *Phys. Rev. E* **90**, 052150, 2014.)

—SKB

Detecting shielded uranium in the field. Security personnel use several methods to detect suspect materials such as explosives and dangerous chemicals (see PHYSICS TODAY, June 2014, page 62). But uranium—especially the highly enriched weapons-grade version—can be difficult to spot because it is easily shielded by a relatively small amount of lead, which absorbs the fissile material's telltale emissions. However, neutrons directed at a suspect object can readily penetrate the lead shielding and produce enough fission neutrons and gamma rays to be detected. For field operations, small and light neutron sources are needed. Jennifer Ellsworth and a team of researchers at Lawrence Livermore National Laboratory (LLNL) have developed a suitcase-sized prototype neutron source that they say can be shrunk to a 5-kg, 20-W, lunchbox-sized device that could be easily transported to inspect a suspicious item. Central to the device is an array of 40 etched iridium tips (in the assembly at left in the figure). The 100-nm-radius tips concentrate the electric field from a com-