up, and the ice sheet behind them is thinning. Measurements of local gravitational anomalies by the GRACE satellites show that the Greenland ice sheet, particularly in its southern reaches, is rapidly losing mass. "The ice sheet is on a diet," Bell says. A lot of Greenland ice is slipping into the Atlantic Ocean.

Do all those effects add up to a tipping point? No one really knows. Investigators are anxiously seeking the answers to two great unknowns about the changes in polar ice. How fast will the ice sheets continue to slide into the sea, and how much more warming will it take to melt the Arctic permafrost? If the permafrost melts, prodigious amounts of trapped methane gas will burp out of the once frozen ground. Twenty years after such a release, methane is 72 times more potent than carbon dioxide ($CO_2$) as a greenhouse gas (after 100 years it remains 25 times more potent than $CO_2$), so if the methane is released, the planet risks a runaway climate catastrophe.

## American Deserts from Melting Ice

The increased rate of Arctic melting could spell trouble for temperate-zone lands. Models predict that if the sea ice disappears by late summer, bands of desert will migrate northward, bringing even drier conditions than at present into the American Southwest, southeastern Europe and the Middle East. According to a study published last year by Julienne Stroeve of the National Snow and Ice Data Center and her colleagues, Arctic sea ice has declined far faster in the past 15 years than models still in use are predicting. Hence, the desertification of midlatitudes may occur before 2050—20 to 40 years sooner than predicted.

MICROBIOLOGY

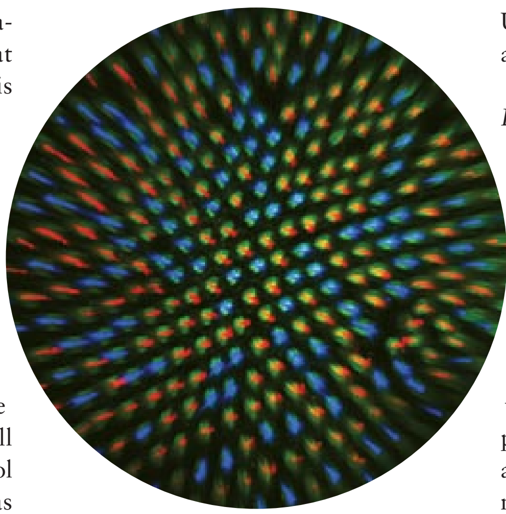
# Bring In the Noise

**New studies reveal how cells exploit biochemical randomness** BY MELINDA WENNER

Just as identical twins raised in the same home often grow up to be different, identical cells grown in the same environment frequently exhibit distinct characteristics. These differences are the result of random fluctuations in biochemical reactions. Biologists had always thought of such biochemical blips as liabilities, but recent studies suggest that cells and bacteria sometimes utilize this randomness to their benefit.

Small systems such as cells are inherently sensitive to the random effects scientists call stochasticity—or noise—because they contain only a few active copies of individual proteins or nucleic acids. Minor fluctuations in the levels of some cellular components, for example, affect whether a particular gene turns on and makes a protein. Such noise seems to suggest that some aspects of cell fate are left to chance; the lack of control forces cells to evolve backup plans, such as redundant biochemical pathways.

Until recently, scientists had trouble studying the phenomenon, because doing so requires the ability to visualize individual cells and molecules; averaging the behavior of groups of cells cancels out noise's effects, much as fabric viewed from a distance looks flawless. In the past decade, however, a handful of new tools, including fluorescent markers that bind to molecules and light up under microscopes, have given scientists the ability to see noise in action.



**RANDOM SIGHTING: Photoreceptor cells in the fruit fly retina have been stained with various colors. Cells with red or blue respond to different hues of light. Developmental randomness ensures that these distinct cell types are distributed throughout the retina.**

CLAUDE DESPLAN *New York University*

What researchers are finding is surprising: cells sometimes appear to use noise to help them survive in changing environments and make decisions during development. "Normally, living things have to cope with noise, but sometimes they exploit it," says Richard Losick, a biologist at Harvard University, who in April co-authored an article on stochasticity in *Science*.

For example, one fifth of bacteria in *Bacillus subtilis* colonies live in a specialized state called competence, in which they stop growing and incorporate DNA from the environment into their genomes. Whether a cell enters this state is determined stochastically, and despite its costs—competent cells do not grow and divide—competence is thought to provide an evolutionary advantage in that it allows a colony to expand its genetic toolbox. Competent cells are most likely "on the prowl for new genetic sequences that could improve their fitness for changed circumstances in the future," Losick remarks.

More complex organisms also use noise to their advantage. The eye of the common fruit fly, *Drosophila melanogaster*, comprises smaller units, each consisting of eight cells. When each cell develops, it makes a choice determined by the presence or absence of a regulatory protein. This protein becomes active only in a random subset of the cells, and its occurrence determines whether the cell will respond to a particular hue of ultraviolet light. Random expression of this regulatory protein ensures that the two cell types are apportioned throughout the eye by chance so as to avoid repetitive patterns that could limit the fly's overall vision. Even though the cells "are in an identical environment and they all come from an identical ancestor, they acquire different phenotypes," or physical traits, says Mads Kaern, a systems biologist at the University of Ottawa.

Although noise plays an important role in a cell's fate, much remains to be learned about the sources of this noise and the extent to which it affects cells and other organisms, including humans. "We know a few [mechanisms], but there's a lot of evidence that there are tons more," notes Edo Kussell, a biophysicist at New York University. Another difficult task will be deciphering their biological relevance. For instance, speculating why bacteria become competent is easy, but proving that speculation is next to impossible. "Can we find a way to demonstrate that a particular stochastic mechanism has really been tuned to evolution? How do we conclusively demonstrate that?" Kussell asks.

As scientists focus on the behavior of individual cells and molecules, another problem arises, too: it becomes difficult to observe processes without affecting them. "We have to do something with the cell in order to analyze it, and we don't really know how those manipulations affect it," Kaern says.

Understanding noise will therefore involve overcoming a number of technological hurdles, but no one doubts that the endeavor is worth the undertaking. Noise could have important implications for many fields, including medicine: if cells and bacteria make a number of their decisions stochastically, then scientists might need to understand noise to develop new antibiotics and to optimize cell-based treatments such as stem cell therapy. "We need to understand how noise works within a network context; how it's used by organisms," Kaern says. "It's a very exciting field—but a little bewildering sometimes."

*Melinda Wenner is a freelance writer based in New York City.*

ENERGY

# Roping the Sun

**Shrugging off massive costs, Japan pursues space-based solar arrays** BY TIM HORNYAK

KAKUDA, JAPAN—In a recent spin-off of the classic Japanese animated series *Mobile Suit Gundam,* the depletion of fossil fuels has forced humanity to turn to space-based solar power generation as global conflicts rage over energy shortages. The sci-fi saga is set in the year 2307, but even now real Japanese scientists are working on the hardware needed to realize orbital generators as a form of clean, renewable energy, with plans to complete a prototype in about 20 years.

The concept of solar panels beaming down energy from space has long been pondered—and long been dismissed as too costly and impractical. But in Japan the seemingly far-fetched scheme has received renewed attention amid the current global energy crisis and concerns about the environment. Last year researchers at the Institute for Laser Technology in Osaka produced up to 180 watts of laser power from sunlight. In February scientists in Hokkaido began ground tests of a power transmission system designed to send energy in microwave form to Earth.

The laser and microwave research projects are two halves of a bold plan for a space solar power system (SSPS) under the aegis of Japan's space agency, the Japan Aerospace Exploration Agency (JAXA). Specifically, by 2030 the agency aims to put into geostationary orbit a solar-power generator that will transmit one gigawatt of energy to Earth, equivalent to the output of a large nuclear power plant. The energy would be sent to the surface in microwave or laser form, where it would be converted into electricity for commercial power grids or stored in the form of hydrogen.

"We're doing this research for commonsense reasons—as a potential solution to the challenges posed by the exhaustion of fossil fuels and global warming," says Hiroaki Suzuki of JAXA's Advanced Mission Research Center, one of about 180 scientists at major Japanese research institutes working on the scheme. JAXA says its potential advantages are straightforward: in space, solar irradiance is five to

## For the U.S., Energy Security in Orbit?

U.S. interest in the concept of orbiting power stations has waxed and waned since it was introduced decades ago. NASA began studying space-based solar power after the mid-1970s oil crisis but axed its research program in 2001. The recent spike in energy prices, though, has rekindled interest. In a feasibility study released last October, the U.S. National Security Space Office urged that the U.S. immediately develop space solar power systems. It noted that "a single kilometer-wide band of geosynchronous Earth orbit experiences enough solar flux in one year to nearly equal the amount of energy contained within all known recoverable conventional oil reserves on Earth today."