called “enhancer regions”—but that these areas also create strands of eRNA potentially vital to creating new connections between neurons.

“Essentially, we think learning requires ‘turning on’ these genes, and the enhancer regions are contributing to that ‘turning on’ process,” Greenberg says. “And [located] at the enhancer regions are these new eRNAs that were unexpected and unknown.” The next step, he says, is determining the exact functions of the eRNAs. Given both their quantity and their ability to affect genes that are already widely believed to affect memory and learning, he expects they will prove essential for learning. Eventually, he says, they could be helpful in everything from athletics (muscle memory) to Trivial Pursuit (declarative memory).

“We want to understand this gene programming in its entirety and how it varies from one human being to another, because we think it’s going to give us some insight into what creates differences in terms of human cognition,” he explains. Deciphering these enhancers that are regulated by experience could provide a new place to look for answers.

Advances in other fields may also aid new discoveries about the root causes of some of the more common cognitive disorders, Greenberg adds. Citing a recent development in stem-cell technology that allows researchers to reprogram any human cell to become an embryonic stem cell, he says it might one day be possible, for example, to take skin-cell samples from two children, one with and one without autism, and then generate an embryonic stem cell from each. If those stem cells were then “directed” to form neurons, they could eventually be stimulated and then sequenced to find out what differences occur in the gene expression pathways. “It seems pretty fanciful,” says Greenberg, “but that’s the kind of research that is happening.”

—DAN MORRELL

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Eventually, enhancer RNAs could be helpful in everything from athletics (muscle memory) to Trivial Pursuit (declarative memory).

Ecosystem Patterns and Productivity

The Kenyan dwarf gecko was what first drew Harvard research fellow Robert M. Pringle to the savannas of Kenya, but the termites kept him there. After he and his co-workers noticed large spikes in these lizard populations surrounding termite mounds, they decided to quantify just how much the mounds enhanced ecosystem productivity.

The presence of termites was already known to increase the number of plant and animal species that a given area could support (largely because they recycle dead organic matter). What startled Pringle was the view from above the savanna. Having noticed that the mounds seemed fairly evenly spaced, he obtained a satellite image of the terrain. It showed clearly that these local hotbeds of activity punctuated the landscape at regularly spaced intervals, as if along a grid. That prompted him to try to answer a deceptive simple follow-up question: Does this patterning actually matter?

Patterns are everywhere in nature, from the ribbons of alpine forests on mountainsides to the complex swirls of

At left: Satellite imagery revealed the grid-like distribution of termite mounds (the small red spots) in the Kenyan savanna. Such patterning optimizes ecosystem productivity. Below: Termites like this soldier, patrolling a piece of fungal comb, aerate and improve the soil near their mounds.

Photographs courtesy of Robert M. Pringle
mussel beds, but proving whether they influence the fundamental properties of ecosystems has been difficult. Pringle wanted to know whether these patterns “really do affect things like productivity, nutrient-cycling rates, and diversity of living forms.”

In a groundbreaking study published recently in PLoS Biology, Pringle says they do, citing the nonrandom distribution of termite mounds over the Kenyan grassland as evidence, based on his collaborators’ and his own statistical simulations. “Where they exist,” he explains, “regular patterns really do scale up to dramatically influence ecosystem function.” The mounds support dense populations of flora and fauna. Plants grow faster the closer they are to the mounds, and animal abundance and reproductive success dropped off with distance. The termites recycle nutrients and, Pringle and his colleagues suspect, they may also improve the soil by introducing coarser particles that help aerate it, simultaneously promoting water infiltration and retention. The even distribution of mounds is vital to this enhanced productivity, suggesting that the lowly termite plays a substantial ecological role alongside the more charismatic fauna of the savanna such as cheetahs or lions.

Pringle’s study is the first to link spatial patterning to the larger-scale properties of an ecosystem, but he expects that rapid technological advances in other domains (particularly chemistry and molecular biology) will likely reveal similar patterns that may generate further research. Besides satellite imagery, he says, “other
kinds of tools—including genetics and, increasingly, geochemical assays—will allow us to shine a much brighter light on how ecosystems are put together and why it matters that they’re put together in that way and not some other way.”

Beyond its importance to ecological scholarship, Pringle’s work has special relevance to both conservation and environmental reconstruction. “Let’s say you’re trying to restore a forest or a coral reef, and to do that you’re planting trees or bits of coral fragment,” he says. “Our results suggest that you want to think hard about the spatial patterning of these transplants—and to remember specifically that even, grid-like, spacing will typically yield the fastest regeneration rates.”

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“Good” Cells Gone “Bad”

The good boy who turns to crime because he lives in a bad neighborhood is a common fixture of popular culture. Now that narrative has a newly discovered analogy in the world of cell biology. Professor of stem cell and regenerative biology and Jordan professor of medicine David Scadden and colleagues have demonstrated for the first time that changes in an environmental niche can actually cause disease. “Good” cells can turn “bad” in a bad neighborhood—leading to cancer.

In cancer, a “single cell goes awry,” explains Scadden. This is thought to happen when the cell accumulates a series of genetic injuries that break down the internal mechanisms controlling such events as how many times it can divide and how long it lives. The cancer then creates daughter cells that can travel and establish new colonies—but not just anywhere. Different kinds of cancers have affinities for colonizing particular organs: prostate cancer goes to bone, breast cancer to brain and lung, pancreatic cancer to liver, for example. This has led scientists to try to define the facilitating properties of those particular surrounding environments.

Scadden has studied the importance of environmental niches in determining cell fate for years. He has shown, for example, that characteristics of a bone microenvironment can determine what type of cell a blood stem cell (in bone marrow) will become. But the idea that the environment could actually be involved in the initiation of a new cancer was not well defined until his recent discovery, which was published in *Nature* earlier this year.

Scadden, who co-chairs the University’s department of stem cell and regenerative biology, found that when he and his team made a genetic alteration in bone cells that surrounded healthy blood stem cells in mice, the mice developed myelodysplasia, a disease that, in humans, frequently leads to an aggressive, generally fatal form of cancer.