the real physiology of eukaryotic cells ... but this aspect of motility is really quite exciting."

While that mystery is being investigated, what's already known about IcsA's role in bacteria could open the way for a *Shigella* vaccine. And that could have important public health implications, because conventional antibiotic remedies against *S. flexneri* and its cousin *S. dysenteriae*—which cause diarrheal epidemics resulting in hundreds of thousands of deaths every year among infants and children in developing countries—are faltering.

Last year Sansonetti sent motionless, tailless *S. flexneri* strains lacking the *icsA* gene to Thomas L. Hale, chief of the Department of Enteric Infections at the Walter Reed Army Institute of Research in Washington, D.C. Hale deleted another gene—one that regulates the bacteria's ability to take up the nutrient iron, thus shortening its lifetime—and recently completed studies showing that this hybrid strain's infectious ability is crippled: It doesn't cause dysentery in rhesus macaque monkeys.

On 11 July, he will begin administering the whole bacteria to 30 human volunteers to find the minimum safe dose of bacteria necessary to evoke an immune response. After pinpointing the safe dose, Hale says, he'll conduct more safety studies in a larger group of volunteers, and then progress sometime next year to "challenge studies" testing vaccinated volunteers' immunity to the unattenuated microbe. "In southern Asia, there are strains of *Shigella* resistant to almost all of the antibiotics normally used against enteric organisms," says Hale. Vaccines based on IcsA mutants "are probably one of the best alternative approaches" to controlling the disease, he says.

Karen Kotloff, an infectious-disease specialist at the University of Maryland's Center for Vaccine Development in Baltimore, says Hale's trials are "very well advised." The *icsA* deletion alone probably would not attenuate *Shigella* sufficiently to make it safe at immunogenic doses, she says, so "using two mutations—one that shortens *Shigella*'s life and another that contains the infection—is a very reasonable approach."

Theriot notes that *S. flexneri* are already "much better cell biologists than humans are." If Hale's approach bears fruit, they may turn out to be better immunologists as well.

–Wade Roush

BIODIVERSITY RESEARCH

Fifty Shades of Rain-Forest Green

On a schoolchild's map of the world, the oceans are colored blue, the Amazon rain forest is green, and the sands of the Sahara are tan. Biologist Hanna Tuomisto of the University of Turku in Finland thinks this kind of child's-paint-box scheme has hampered creative thinking about the Amazon basin for years, as many researchers treated all 4 million square kilometers of the rain forest as a homogeneous block.

On page 63, Tuomisto and colleagues present an attempt to change such monolithic views, using new data from satellite images and laborious field surveys. Their results reveal that maps of the Peruvian Amazon ought to be colored in not one but perhaps 50 shades of green to indicate a patchwork of different forest types. "They're addressing the conventional view of the rain forest as homogeneous, as the green hell on a map," says Paul Colinvaux, a tropical ecologist at the Smithsonian Tropical Research Institute in Panama. "We very badly needed this kind of data." This new picture of the Amazon also has implications for some key ecological issues: How did so many species arise in the rain forests—and how can they be saved now?

Tuomisto and an interdisciplinary team from Finland and Peru explored the Peruvian Amazon at scales ranging from a meter to hundreds of kilometers. For the small-scale studies, they spent five field seasons in tent camps, walking transects and sampling soils, ferns, shrubs, and trees. They found that the mix of species varied according to soil fertility and topography. Valleys had more diversity than hills, for example, and forests growing on different soils had different species compositions.

This close-up view was buttressed by the team's analysis of Landsat images, in which false color patterns are created by physical properties of soil and vegetation. If the forest were homogeneous, each pixel in a satellite image would be the same color as its neighbors, explains Tuomisto. Instead, the team saw a mosaic of colors worthy of a Seurat painting. On average, a 30-kilometer transect contained four colors or habitats. In a single 34,000-square-kilometer image, as many as 54 distinct habitats were visible. All this means that the Amazon forest is more heterogeneous than it looks, says Tuomisto.

To be fair, other ecologists who have scrambled their way through the jungle, especially in Southeast Asia, know that rain forests aren't homogeneous, says forest ecologist Stephen Hubbell of Princeton University. But he says the new work offers a much-needed method to survey large-scale variability. "We need to pay much more attention to the way diversity is arranged on landscapes, and so we need to scale up. And that's just what they've done," he says.

The work also has implications for the enduring mystery of how tropical rain forests acquired their remarkable biological diversity. "The majority opinion has been that the rain forests have high species diversity despite very little physical variation," explains Tuomisto. So biologists have postulated that today's forests contain species-rich areas that are relics of the ice ages, when the climate was drier and forests shrank into small refuges. According to this theory, those refugia became centers of speciation thousands of years ago and retain great diversity today.

The new study suggests a simpler explanation: Diversity of habitat, created by physical factors, led to the wealth of species. "The problem has been, if the Amazon is one huge forest, how do you get such disjunct distributions," says Colinvaux. "And now they're saying that it's not one huge forest; it's heterogeneous. This makes the refugium hypothesis unnecessary."

But the new data don't refute that hypothesis, counters Hubbell. In fact, he says, the two ideas are not mutually exclusive, because Ice Age soils presumably varied too. Tuomisto agrees, saying it's premature to chuck out any theories. The next step is to verify and define the physical factors behind the Landsat color patterns. The team suspects topography and soils play a role—but they'll need a massive field effort to prove it.

H. TUOMISTO

Mixed greens. On this Peruvian hill some tree canopies are densely packed, while others stand out individually.

"This is the tip of the iceberg. It will take lots more ground-truthing to refine the method," says Hubbell.

A highly heterogeneous forest also supports a new philosophy in conservation biology: Diversity of habitats, as well as sheer numbers of species, should be considered when creating biodiversity preserves. "You should get a reasonable sample of all the habitats into the conservation program, even if some habitats have relatively fewer species," says Tuomisto. Debate on such issues is likely to continue. But it's already clear that would-be artists painting Amazonia will have to expand their palettes beyond a single shade of green.

–Elizabeth Culotta