teria can also provoke an immune response in which, among other things, they release lectins, sugar-binding antibody-like molecules found in many other creatures including crustaceans and starfish. As lectins circulate in the hemolymph, an insect's version of blood, they presumably aid the immune response by attaching to foreign substances and marking them for phagocytosis. Cockroaches, giant silkmoths, tobacco hornworms, and other insects also rely on at least one other mechanism to combat infection: a variety of defensive peptides such as the antibacterial agents known as cecropins.

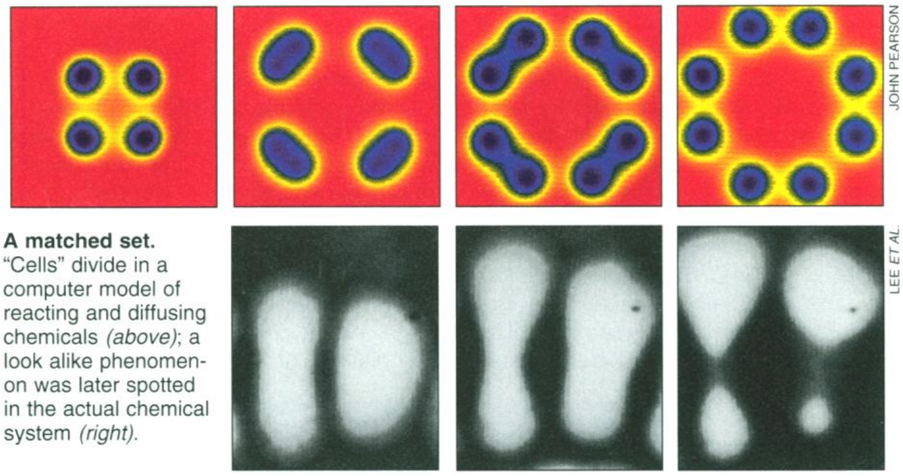
The panoply of immune strategies found in simpler organisms adds to the intellectual appeal of comparative immunology—but may also impede its progress. Compared to mammalian immunology, we have advanced "a bit slower because we have fewer people and almost everyone of us is working on different models," notes comparative immunologist Edwin Cooper of the University of California, Los Angeles. And those involved in moving the subject forward face a constant battle to attract new students and funding at a time when "relevant" research is prized. "Why study a worm, when you can study a mouse? That's what people are fighting," says Zasloff. But as Metchnikoff showed more than a century ago, the fight is worthwhile.

–John Travis

CHEMISTRY

A Chemical Loom Weaves New Patterns

A universe without patterns would be about as intellectually stimulating as a vat of mashed potatoes. There would be no spiral galaxies, no crystal lattices, no zebra stripes, no organized structures of any kind and no scientists trying to explain the whys and wherefores of such patterns. Which is why systems of reacting chemicals that spawn vivid patterns catch the eyes of more than just the researchers studying the reaction. Something very basic about the pattern-populated universe might be showing itself; on the other hand, the patterns might be nothing more than pretty pictures painted by chemistry. Which are they? This week's *Science* raises that question with two reports on pattern-forming systems that exhibit a combination of stability and change reminiscent of pattern formation in living things.



A matched set. "Cells" divide in a computer model of reacting and diffusing chemicals *(above)*; a look alike phenomenon was later spotted in the actual chemical system *(right)*.

In one paper (p. 192), experimentalists at the University of Texas, Austin, report that a homogeneous, well-mixed solution of reacting chemicals (an iodate-ferrocyanide-sulfite system) evolves over several hours into an irregular pattern of curvy, interdigitating light and dark regions. In the other (p. 189), a theorist at the Los Alamos National Laboratory describes a model chemical system that, in a computer, behaves much like the real chemistry seen in Austin. But just what the match may reveal about the actual chemical system—or about pattern formation in nature—is still anybody's guess.

Pattern-forming chemical reactions have been studied since the late 1960s. Even before then, in 1952, the British mathematician Alan Turing speculated about their existence and suggested that the reactions could underlie biological patterns such as creaturely architecture and hide coloring. But both the real and the simulated reactions reported here seem to display a new kind of pattern-forming behavior, says Ken Showalter, a chemist studying pattern-forming chemical reactions at West Virginia University, Morgantown.

Some earlier systems never freeze into a final stable pattern. Instead they may oscillate between different states until they peter out, or their spiraling arms may meet and annihilate each other. Others, reported in 1990 by Patrick De Kepper and colleagues at the University of Bordeaux and later by others, yield the fixed patterns of dots or stripes Turing had predicted. The Turing patterns emerge everywhere at once in the reaction medium, like a slowly developing negative. But in the new experiments, patterns spread out like an avalanche from a site of initial activity—and then reach a stable state.

To create these patterns, the Austin group, led by physicist Harry Swinney, allows the solution of reactants to permeate a thin slab of polyacrylamide gel, which suppresses convective motions. They then expose one edge of the gel to ultraviolet light. The light triggers a complex nexus of reactions that drives up the pH of the illuminated area, causing a pH-sensitive indicator to darken. The disturbance propagates as a traveling wave front with a snaky leading edge, from which projections grow outward like fingers and approach each other without touching, as though a thin demilitarized zone were keeping them at bay. After several hours, the result is a stable, maze-like pattern of dark and light regions.

As in all pattern-forming reactions, some interplay between the rate at which specific chemical reactions take place and the rate at which reactants diffuse through the medium must be at work. But Richard Noyes of the University of Oregon, who has studied pattern-forming reactions since the late 1960s, thinks the details of the process must be new. "I'm used to seeing these waves come together and annihilate," he says.

Finding clues to what underlies the novelty is what John Pearson of the Los Alamos National Laboratory aims to do in the second paper. Pearson adapted a well-known model based on equations that describe how chemicals react and diffuse to resemble the two-dimensional gel system of the Austin group. He then "disturbed" the simulation by adding an extra shot of one reactant to the central region. "I give it a hard kick and then find out what happens," he says. A variety of patterns unfurled, some looking very much like the patterns observed by Swinney's group.

The model also predicted new patterns: sets of self-replicating dots that roughly resemble dividing cells. That prediction inspired the Austin group to run additional experiments after their paper went to press. The result: "We now have found replicating spots," Swinney told *Science* (see photo). In spite of that validation, Noyes recommends caution. A model's success is never a guarantee that it has much basis in reality, he says; conceivably, "the two papers may have nothing to do with each other." Still, many observers agree that the striking visual similarity between dividing cells and the replicating dots in the chemical and computerized systems is breathing new life into Alan Turing's 40-year-old conjecture.

–Ivan Amato