Stressed bacteria spawn elegant colonies

Colonies of bacteria under stress form striking patterns. Put them on an inhospitable surface and a lean diet, and they spread out into elaborate networks, presumably in arrangements that enhance their survival.

But exactly how and why bacteria make these extraordinary patterns remains unexplained. How do they signal each other? By what mechanism do they respond to attractants or repellents? In what way does clumping together in rings help them use available resources more efficiently?

Lev Tsimring and Herbert Levine, physicists at the University of California, San Diego, and their colleagues propose a model to explain this bacterial behavior. By means of computer graphics, their model—based on diffusion processes in nonliving chemical systems—produces patterns quite similar to those observed in live bacteria.

The physicists detail their results in the Aug. 28 PHYSICAL REVIEW LETTERS.

When deprived of nutrients, colonies of *Escherichia coli* spawn stripes and rings as the microorganisms react to each other and to their environment. Presumably, they move toward food and neighboring bacteria and away from biological waste, yielding regular spacings, the researchers believe.

To simulate this phenomenon, the physicists invoke a chemical diffusion model first proposed by mathematician Alan Turing in the 1950s. Applied to bacteria, the model emphasizes feedback mechanisms, based on the interplay of chemical attractants and repellents. The fact that the computer simulations mimic patterns observed in live colonies of bacteria leads the physicists to conclude that "generic mechanisms" may be at work.

"Not much is known about how cells communicate with each other chemically," Levine says. "So in these biological structures, we're using reverse logic. We're working backwards from observed patterns in living systems to those seen in nonliving systems in an effort to determine what physical mechanisms must be at work."

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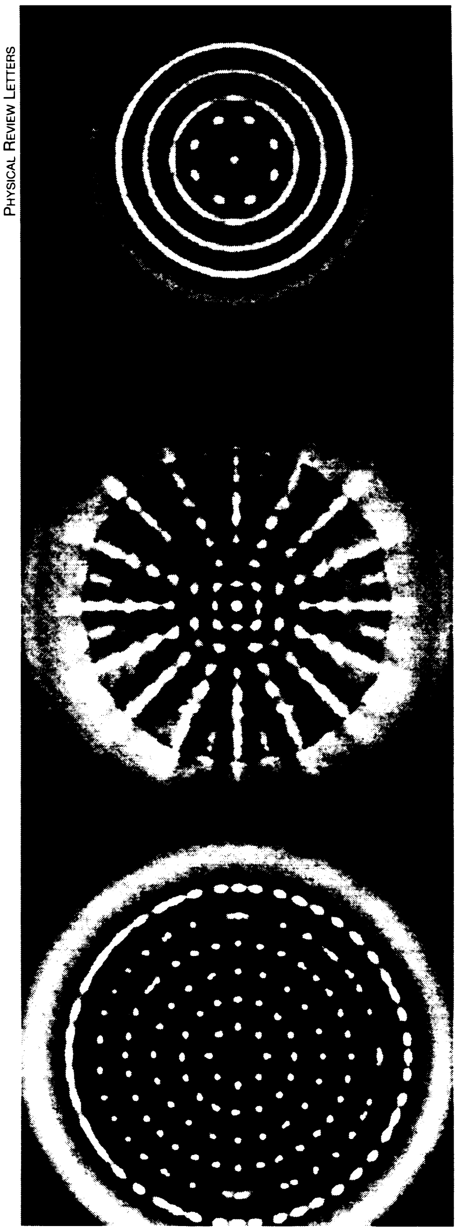

Simulations of bacterial growth resemble patterns of live colonies.

But do these models actually represent bacterial biochemistry? "It's hard to say," says Howard C. Berg, a biologist at Harvard University who, with biologist Elena O. Budrene, first reported such bacterial patterns in 1991 (SN: 3/4/95, p.136).

"It's definitely worthwhile to look at these patterns from a chemical systems point of view. But whether this model has anything to do with how cells organize and develop themselves is still a matter in question.

"It's possible that they're right," Berg continues. "But we don't know yet. We have to do more experiments in the laboratory with bacteria to test their hypothesis." —*R. Lipkin*

Progressing to a set of consecutive primes

Searches for patterns among prime numbers have long served as stiff tests of the ingenuity and perseverance of mathematicians. In recent years, the use of computers in these prime pursuits has brought a steady stream of novel results.

Last week, Harvey Dubner, a semiretired electrical engineer in Westwood, N.J., and Harry L. Nelson, now retired from the Lawrence Livermore (Calif.) National Laboratory, added a new entry to the prime-number record book. They announced that they had found seven consecutive primes in arithmetic progression. The previous record had been six.

In other words, Dubner and Nelson unearthed a sequence of seven prime numbers—whole numbers exactly divisible only by themselves and one—in which each successive number is 210 larger than its predecessor, starting with the following 97-digit prime: 1, 089, 533, 431, 247, 059, 310, 875, 780, 378, 922, 957, 732, 908, 036, 492, 993, 138, 195, 385, 213, 105, 561, 742, 150, 447, 308, 967, 213, 141, 717, 486, 151.

Nelson had the idea of looking for such a string of consecutive primes after reading about these sequences in *The Book of Prime Number Records* (1989, Paulo Ribenboim, Springer-Verlag). Mathematicians and others had identified numerous examples involving six consecutive primes in arithmetic progression, but no examples of seven.

Nelson suggested the problem to Dubner, who had several personal computers specially modified and programmed to handle computations involving prime numbers (SN: 11/20/93, p.331). For mathematical reasons, they knew that the primes they were looking for had to be at least 210 apart, and they reasoned that numbers 90 to 100 digits long would be a good place to search for the required pattern.

Initially, Dubner thought that the computations would take too long to be practical. But Nelson introduced a mathematical shortcut—a way of eliminating a large proportion of the candidate numbers—that considerably reduced the computation time needed for the search.

Dubner ended up using seven computers, running continuously for about 2 weeks, to find the sequence.

Now, Dubner and Nelson are thinking about taking the next step: going to eight consecutive primes in arithmetic progression. Dubner estimates that it would take about 20 times longer—at least 2.5 computer-years—to accomplish this search on his souped-up personal computers.

"But we can probably improve our method," Nelson says. "We need some advice from number theorists." By using better techniques and a larger number of computers, "there's a very real possibility that you could go to 10 consecutive primes," he adds.

Finding sequences of 11 or more such primes is vastly more difficult, however. Candidate numbers would have to be at least 1,000 digits long, Nelson estimates.

At the same time, there's probably no end in sight. Mathematicians have conjectured (but not yet proved) that in the infinite universe of whole numbers, there is no limit to the number of consecutive primes in arithmetic progression.

—*I. Peterson*