

ria to interact with the fungi and thus spread across the surfaces of the cheeses, Wolfe points out. For instance, proteobacteria within cheeses alter their nitrogen metabolism, while downregulating chitinases, suggesting a symbiotic relationship to protect their fungal partners. “Several bacteria grew poorly without the presence of a fungal partner, demonstrating that the cheese environment may be unable to support the growth of some bacteria,” he says. However, this seeming deficiency is “rectified by the presence of several different genera of fungi.”

*Shannon Weiman is a freelance writer in San Francisco, Calif.*

#### RESEARCH ADVANCES

### Simulating Microbiome Activities in Silico—with Robots as Hosts

**Barry E. DiGregorio**

Because the interactions and influences between host and microbiome sometimes prove too complex to analyze directly, one simplifying alternative is to model them in silico, according to Warren C. Ruder of Virginia Polytechnic Institute and State University (Virginia Tech) in Blacksburg, Va., and his collaborators. Their approach “computationally simulates a hybrid robot-bacteria system,” and this virtual host-and-microbiome duet appears to “replicate a range of different biological ‘host’ behaviors,” they report. Details appeared in the July 2015 *Scientific Reports* (doi:10.1038/srep11988.)

In other words, the model incorporates an engineered bacterial population to stand in for the microbiome, while the robot stands in for an animal host, according to Ruder. “In our simulations, we borrowed *Escherichia coli* signaling machinery that drives the bacteria’s desire to acquire lactose or arabinose, but we modeled the system with normal culture media,” he says. The “host”—that is, the computer-sim-

ulated robot—was equipped with sensors and a miniature microscope.

This model system allows its users to make simple changes to engineered gene networks in the bacteria that are part of the virtual microbiome or to the host robot’s programming, and then watch complex behaviors emerge within the overall model, Ruder says. Such computer simulations belong to the growing field of synthetic biology, whose virtual birth traces more or less to the year 2000.

“In most simulations, the robot was passive and simply took commands,” Ruder says. “When we programmed it with a single additional subroutine whereby it detected when it got close to a fuel depot and injected a biochemical into the bioreactor, we saw a new behavior. The result was a system that exhibited stalk-pause-strike behavior. This showed that simple additions to the genetic circuitry and robot programming caused relatively complex behavior to emerge.”

“By integrating an engineered microbiome, a microfluidic chemostat mimicking the microbiome’s environment within an organism, and a robotic conveyance, we have designed, modeled, and simulated a biomimetic system that allows us to explore natural phenomena through both synthetic biological and robotic programming,” note Ruder and his collaborators. “We expect this model system will have implications in fields ranging from synthetic biology and ecology to mobile robotics.”

“The work will serve as a good foundation for other researchers in the fields of computational systems biology or synthetic biology,” says Rahul Sarpeshkar at Dartmouth College in Hanover, N.H. “Such control systems are very important in enabling these fields to engineer and to understand the noisy, analog, and complex feedback dynamical systems actually seen in living cells.” And adds **Vikas Berry** at the University of Illinois, Chicago, “I believe that a prototype of the pro-

#### MINITOPIC

### FDA Finalizes First Two of Seven Food Safety Rules under FSMA

Officials of the Food and Drug Administration (FDA) in September finalized the first two of seven rules addressing how to prevent foodborne illnesses under the FDA Food Safety Modernization Act (FSMA), which was signed into law early in 2011 (*Microbe*, March 2011, p. 108). These first two rules focus on implementing modern manufacturing processes for both human and animal foods by requiring food production facilities to develop and implement written food safety plans. It further specifies that companies describe anticipated food safety problems and also outline steps to prevent or minimize those problems. The new rules are expected to reduce some of the burden of foodborne illnesses that officials of the Centers for Disease Control and Prevention estimate to affect 48 million Americans, leading to some 3,000 fatalities and as many as 128,000 hospitalized cases each year. FDA plans to finalize five additional FSMA rules sometime during 2016.

posed model can be built in a year or two. However, the complete development of this ‘biotechnology’ and the realization of the vast variety of functions and operations that can be possible will take a few decades of work.”

*Barry E. DiGregorio is a freelance writer in Middleport, N.Y.*

#### SCIENCE AWARDS

### Lasker, National Academy “Convergence” 2015 Awards Recognize Microbiology

**Jeffrey L. Fox**

The 2015 Lasker Awards in several categories recognize microbiologists and