Researchers track evolution through snapshots of 40,000 generations

The experiment, bane of Conservapedians, traces evolution to the DNA level.

by **John Timmer** - Sept 19 2012, 1:00pm EDT

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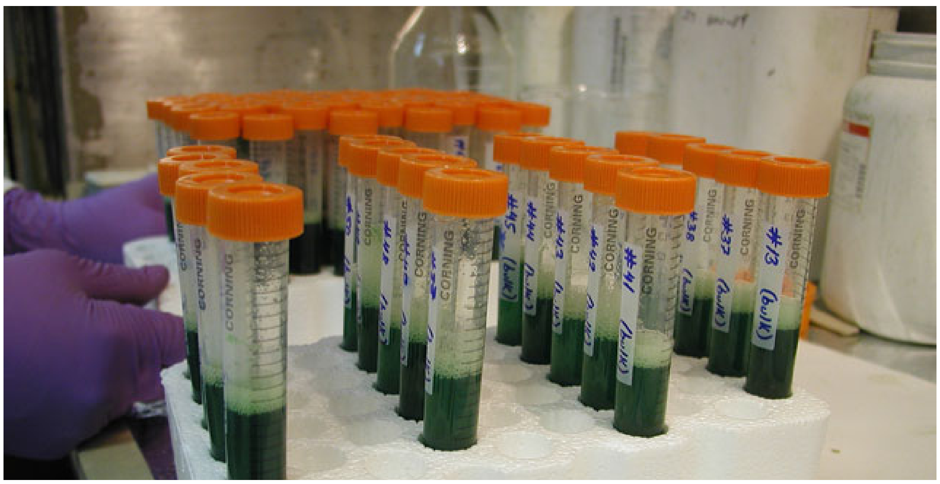

DNA extraction from a maize leaf sample.

CIMMYT

In 1988, Richard Lenski's lab began an experiment. A set of 12 bacterial cultures were started, but only given enough sugar to keep them growing for a few hours. The next day, the bacteria were again given another burst of sugar. And the process has been repeated every day since. The goal? To be able to follow major evolutionary innovations as bacteria try to outcompete their peers under near-starvation.

Back in 2008, one of the 12 cultures had its big breakthrough, a sudden burst of growth powered by citrate, a chemical that was present in the mix, but not normally used by bacteria (a result that was hilariously contested by the founders of Conservapedia). Now, Lenski is benefitting from a technology that didn't exist when he started the work—whole genome sequencing—and reconstructing exactly how the bacteria evolved the new ability.

The team behind the latest work took advantage of the fact that the experiment has involved taking snapshots of the bacteria every few thousand generations, simply by siphoning a few off and sticking them in the freezer. These bacteria can be used to figure out what the status of the genomes were at a given generation, or even grown again, to see whether the same evolutionary history can take place.

In the new paper, the authors sequence the genomes of 29 different clones of bacteria, obtained from various points in the culture's history. One distinct genetic lineage appeared in the culture a bit before 10,000 generations but had apparently died off before 20,000 generations, never to be seen again (the authors called this UC, for "unsuccessful clade"). Three large groups of related strains still persist in the cultures, but only one of them has citrate-eating bacteria, which evolved sometime around 31,000 generations in.

The first citrate-eating bacteria appear to have left a lot of descendants, since that group has diversified rapidly (although it hasn't completely killed off its competition). In fact, one branch of the citrate eaters has picked up a mutation that wipes out a gene involved in DNA repair, which causes an increased rate of mutation and an even faster diversification.

The genomes also let the researchers figure out exactly how citrate eating evolved. The *E. coli* used in the experiment actually have a gene that brings citrate inside the cell, but it's normally shut down when oxygen is present. In the first citrate eaters, a bad duplication of this gene made an extra copy, but put it under the control of regulatory DNA for a neighboring gene. This worked, in that the new control sequence expressed the gene even when oxygen was around, but it didn't work well. The resulting bacteria only had a one percent advantage in reproductive success relative to their peers.

Things accelerated afterwards, as further duplications put more and more copies of the newly generated gene into the genomes. By the time there were three copies of this gene present, the bacteria had a large competitive advantage. Presumably, somewhere in Michigan, their descendants are fine-tuning that ability even as you read this.

On its own, this would be a great story, as the researchers have traced the evolution of a complex trait that's so rare that it took tens of thousands of generations of bacteria to produce it. But the authors also show there's still a bit of mystery to their system. They had previously showed that some specific change had occurred somewhere near 20,000 generations that made evolving citrate-eating more probable.

So, the authors took a copy of the newly evolved citrate transporter gene, and inserted it into bacteria from earlier in the history. Although it worked, in that they could eat citrate, it worked very poorly. The same problem occurred when the gene was placed in lineages that had split off prior to 20,000 generations. So, what happened at 20,000 generations that makes citrate easier to deal with?

They don't know. Sequencing the genomes reveal a variety of changes, but none of them would obviously make digesting citrate easier. So, even as this experiment goes on, it's got some of the researchers scratching their heads about its past.

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John Timmer / John became Ars Technica's science editor in 2007 after spending 15 years doing biology research at places like Berkeley and Cornell.

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