Time in a bottle: Scientists watch evolution unfold

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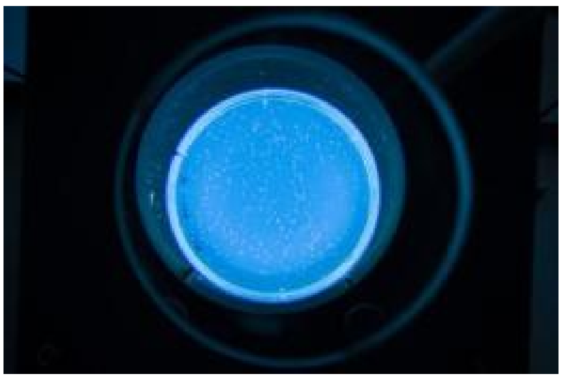

E. coli cultures in the laboratory of Michigan State University evolutionary biologist Richard Lenski. Credit: Greg Kohuth, Michigan State University

A 21-year Michigan State University experiment that distills the essence of evolution in laboratory flasks not only demonstrates natural selection at work, but could lead to biotechnology and medical research advances, researchers said.

Charles Darwin's seminal Origin of Species first laid out the case for evolution exactly 150 years ago. Now, MSU professor Richard Lenski and colleagues document the process in their analysis of 40,000 generations of bacteria, published this week in the international science journal *Nature*.

Lenski, Hannah Professor of Microbial Ecology at MSU, started growing cultures of fast-reproducing, single-celled *E. coli* bacteria in 1988. If a genetic mutation gives a cell an advantage in competition for food, he reasoned, it should dominate the entire culture. While Darwin's theory of natural selection is supported by other studies, it has never before been studied for so many cycles and in such detail.

"It's extra nice now to be able to show precisely how selection has changed the genomes of these bacteria, step by step over tens of thousands of generations," Lenski said.

Lenski's team periodically froze bacteria for later study, and technology has since developed to allow complete genetic sequencing. By the 20,000-generation midpoint, researchers discovered 45 mutations among surviving cells. Those mutations, according to Darwin's theory, should have conferred some advantage, and that's exactly what the researchers found.

The results "beautifully emphasize the succession of mutational events that allowed these organisms to climb toward higher and higher efficiency in their environment," noted Dominique Schneider, a molecular geneticist at the Université Joseph Fourier in Grenoble, France.

Lenski's long-running experiment itself is uniquely suited to answer some critical questions -- such as whether rates of change in a bacteria's genome move in tandem with its fitness to survive.

Michigan State University Richard Lenski, standing, analyzes *E. coli* cultures with postdoctoral researcher Jeffrey Barrick. Credit: Greg Kohuth, Michigan State University

"The coupling between genomic and adaptive evolution is complex and can be counterintuitive," Lenski concluded. "The genome was evolving along at a surprisingly constant rate, even as the adaptation of the bacteria slowed down a lot. But then suddenly the mutation rate jumped way up, and a new dynamic relationship was established."

A mutation involved in DNA metabolism arose around generation 26,000, causing the mutation rate everywhere else in the genome to increase dramatically. The number of mutations jumped to 653 by generation 40,000, but researchers surmise that most of the late-evolving mutations were not helpful to the bacteria.

Gene mutations involved in human DNA replication are involved in some cancers. Many of the patterns observed in the experiment also occur in certain microbial infections, "and cancer progression is a fundamentally similar evolutionary process," observed collaborator

Jeffrey Barrick. "So what we learn here can help us better understand the course of these diseases."

Barrick, a postdoctoral researcher in MSU's Department of Microbiology and Molecular Genetics, developed computational tools to discover and validate often complex mutations. "We know an astounding amount about the details of evolution in these little Erlenmeyer flasks," he said.

The *Nature* paper involved collaboration with scientists from South Korea as well as France and MSU. The research, said genomics team leader Jihyun Kim of the Korea Research Institute of Bioscience and Biotechnology, "is not only useful in understanding the tempo and mode of evolution, but can serve as a nice framework for practical applications in biotechnology, such as improving the performance or productivity of an industrial strain."

Thousands of generations later, the MSU experiment continues to evolve. "Like a lot of science, our study answers some questions but raises many others," Lenski said.

Source: Michigan State University (news : web)

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