



Escherichia Coli Helps Researchers Understand How Organisms Evolve New Functions

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[April Flowers](#) for redOrbit.com – Your Universe Online

[Michigan State University](#) researchers and colleagues from the [University of Texas](#) and the [University of Calgary](#) have documented the step-by-step process in which organisms evolve new functions.

The study results are revealed through an in-depth, genomics-based analysis that decodes how [E. coli](#) bacteria figured out how to supplement a traditional diet of glucose with an extra course of citrate.

“It’s pretty nifty to see a new biological function evolve,” said Zachary Blount, postdoctoral researcher in MSU’s [BEACON](#) Center for the Study of Evolution in Action. “The first citrate-eaters were just barely able to grow on the citrate, but they got much better over time. We wanted to understand the changes that allowed the bacteria to evolve this new ability. We were lucky to have a system that allowed us to do so.”

If oxygen is present, normal E. coli can’t digest citrate. It’s a distinctive hallmark of E. coli that they can’t eat citrate because the E. coli doesn’t express the right protein to absorb citrate molecules.

To decipher the responsible mutations, Blount worked with Richard Lenski on Lenski’s long-term experiment, cultivating cultures of fast-growing E. coli. Launched in 1988, the project has allowed Lenski and his colleagues to study more than 56,000 generations of bacterial evolution.

The experiment demonstrates [natural selection](#) at work. And because samples are frozen and available for later study, when something new emerges scientists can go back to earlier generations to look for the steps that happened along the way.

“We first saw the citrate-using bacteria around 33,000 generations,” Lenski explained. “But Zack was able to show that some of the important mutations had already occurred before then by replaying evolution from different intermediate stages. He showed you could re-evolve the citrate-eaters, but only after some of the other pieces of the puzzle were in place.”

The research, published in [Nature](#), analyzed 29 genomes from different generations to find the mutational pieces of the puzzle to uncover a three-step process in which the bacteria developed this new ability.

Potentiation is the first step, when the E. coli accumulated at least two mutations that set the stage for later events. Then came actualization, when the bacteria first began eating citrate but only just nibbling at it. The final stage, refinement, involved mutations that greatly improved the initially weak function. This allowed the citrate eaters to devour their new food source, becoming dominant in the population.

“We were particularly excited about the actualization stage,” Blount said. “The actual mutation involved is quite complex. It re-arranged part of the bacteria’s DNA, making a new regulatory module that had not

existed before. This new module causes the production of a protein that allows the bacteria to bring citrate into the cell when oxygen is present. That is a new trick for *E. coli*.”

The change was far from normal, Lenski said.

“It wasn’t a typical mutation at all, where just one base-pair, one letter, in the genome is changed,” he said. “Instead, part of the genome was copied so that two chunks of DNA were stitched together in a new way. One chunk encoded a protein to get citrate into the cell, and the other chunk caused that protein to be expressed.”