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Tortoise and Hare, in a Laboratory Flask

By CARL ZIMMER

Ever since Darwin, biologists have recognized that life evolves. But in the past 25 years, some researchers have argued that certain organisms are better at evolving than others. Their genomes have a flexibility that lets them adapt effectively. The less evolvable species, by contrast, are too rigid to take advantage of new mutations or to find new solutions for survival.

Many biologists agree that evolvability makes sense in theory. But finding evidence of it in the natural world has proved difficult. Part of the problem is that natural selection can take a long time to act on a species. It is also difficult for researchers to identify the mutations underlying evolution. But in the latest issue of Science, a team of researchers reports a detailed example of evolvability in action, one that took place before their own eyes in a laboratory.

“I think it’s a brilliant piece of work,” said Massimo Pigliucci, a leading researcher on evolvability who teaches at Lehman College in the Bronx.

The new study emerged from the longest continuous experiment on evolution, which began in 1988 when Richard E. Lenski, now at Michigan State University, seeded 12 flasks with genetically identical copies of E. coli. He and his colleagues have reared the bacteria on a meager diet of glucose ever since.

Over the course of 52,000 generations, the bacteria have adapted to their peculiar environment. Every 500 generations, Dr. Lenski and his colleagues freeze some of the bacteria, which they can thaw years later to compare with their evolved descendants.

Dr. Lenski and his colleagues picked out one of the 12 lines for especially close study. “We wanted to trace the order in which mutations appeared and make sense of all that,” he said.

The scientists observed that after 500 generations, two types of E. coli were dominant in the flask, each with a distinctive set of mutations. After 1,000 generations, however, only one type was left. Dr. Lenski and his colleagues dubbed them the “eventual winners.”

They wanted to chart the course of that victory over the eventual losers. They thawed both types from the 500th generation and had them compete against each other. They expected the result to be a foregone conclusion: the eventual winners would already be showing their superiority. But they ran the experiment anyway, for the sake of thoroughness.

“We said, ‘Let’s dot our i’s and cross our t’s,’ ” Dr. Lenski said.

To their surprise, they were wrong. At the 500th generation, the eventual losers were far superior, growing 6.5 percent faster than the eventual winners. At that rate, they should have driven the eventual winners to extinction in 350 generations.

The scientists saw two possible explanations for the turnaround. One was that the eventual winners were more evolvable: they had more potential to increase their growth rate, allowing them to come from behind and win the evolutionary race.

The other possibility was that the eventual winners were just lucky, that at some point after the 500th generation they developed beneficial mutations that let them pull ahead.

“A weaker player in a game of cards may beat a better player once in a while just because they got dealt a royal flush,” Dr. Lenski said.

He and his colleagues set up a new experiment to choose between the two possibilities. They thawed some of the eventual winners from the 500th generation and used them to start 20 new lines of bacteria. Likewise, they started 20 other lines with the eventual losers. Then the scientists allowed all the thawed bacteria to reproduce for 883 generations.

The eventual winners still consistently beat out the eventual losers, the researchers found. On average, they ended up growing 2.1 percent faster than their rivals. Their success, in other words, was not the result of good fortune. They were better prepared to make the most of beneficial mutations.

The experiments have allowed the scientists to reconstruct the evolutionary race. The eventual losers initially pulled into the lead with mutations that gave them a short-term increase in their growth rate. But those mutations set them up for long-term defeat because when the additional beneficial mutations appeared, the losers enjoyed only a small increase in their growth rates.

The eventual winners, on the other hand, got a big benefit from later mutations, allowing them to pull ahead and take over the flask.

Dr. Pigliucci said that evolvability could explain a number of important patterns in nature, like why some animals come in many different forms while their close relatives have not changed much in hundreds of millions of years. That would mean that evolvability would need to be present in the generation-by-generation struggle for survival. And Dr. Lenski's experiment documents that it can indeed make a difference for real organisms.

"That right there is a big deal," he said.