Darwin in a test tube: Scientists make molecules that evolve, compete, mimick behavior of Darwin's finches

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As described in an article published this week in an advance, online edition of the journal *Proceedings of the National Academy of Sciences* (PNAS), the work demonstrates some of the classic principles of evolution. For instance, research shows that when different species directly compete for the same finite resource, only the fittest will survive. The work also demonstrates how, when given a variety of resources, the different species will evolve to become increasingly specialized, each filling different niches within their common ecosystem.

Conducted by Sarah Voytek, Ph.D., a recent graduate of the Scripps Research Kellogg School of Science and Technology, the work is intended to advance understanding of Darwinian evolution. Using molecules rather than living species offers a robust way to do this because it allows the forces of evolution to work over the course of mere days, with a trillion molecules in a test tube replicating every few minutes.

"We can study things very quickly," says Scripps Research Professor Gerald Joyce, M.D., Ph.D., who was Voytek's advisor and her coauthor on the paper. Joyce is the dean of the faculty at Scripps Research, where he is also a professor in the Department of Molecular Biology, the Department of Chemistry, and The Skaggs Institute for Chemical Biology.

On the voyage of the HMS Beagle, Darwin collected and studied different species of finches on several of the Galapagos Islands. The finches differed in their beak structure — some had thick, strong beaks and others had thin, delicate ones. Darwin observed that the different finches were each adapted for the specific types of seeds that served as their primary food source. The big-beaked birds were indigenous to the places where the big seeds grew; in areas where there were also small seeds, there were also small-beaked birds. Darwin reasoned that the finches had a common ancestor but had separated into different species — a classic concept in Darwinian evolution known as "niche partitioning," which holds that when two species are competing for resources within a common environment, they become differentiated so that each species adapts to use different preferred resources.

For several years, Joyce has been experimenting with a particular type of enzymatic RNA molecule that can continuously evolve in the test tube. The basis of this evolution comes from the fact that each time one of the molecules replicates, there is a chance it will mutate — typically about once per round of replication — so the population can acquire new traits over time.

Two years ago, Voytek managed to develop a second, unrelated enzymatic RNA molecule that also can continuously evolve. This allowed her to set the two RNAs in evolutionary motion within the same pot, forcing them to compete for common resources, just like two species of finches on an island in the Galapagos.

In the new study, the key resource or "food" was a supply of molecules necessary for each RNA's replication. The RNAs will only replicate if they have catalyzed attachment of themselves to these food molecules. So long as the RNAs have ample food, they will replicate, and as they replicate, they will mutate. Over time, as these mutations accumulate, new forms emerge — some fitter than others.

When Voytek and Joyce pitted the two RNA molecules in a head-to-head competition for a single food source, they found that the molecules that were better adapted to use a particular food won out. The less fit RNA disappeared over time. Then they placed the two RNA molecules together in a pot with five different food sources, none of which they had encountered previously. At the beginning of the experiment each RNA could utilize all five types of food — but none of these were utilized particularly well. After hundreds of generations of evolution, however, the two molecules each became independently adapted to use a different one of the five food sources. Their preferences were mutually exclusive — each highly preferred its own food source and shunned the other molecule's food source.

In the process, the molecules evolved different evolutionary approaches to achieving their ends. One became super efficient at gobbling up its food, doing so at a rate that was about a hundred times faster than the other. The other was slower at acquiring food, but produced about three times more progeny per generation. These are both examples of classic evolutionary strategies for survival, says Joyce.

More information: "Niche partitioning in the coevolution of 2 distinct RNA enzymes," Proceedings of the National Academy of Sciences

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