Researchers devise way to calculate rates of evolution

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"Survival of the fittest" has popularly described evolution for more than a century, but a new study published in the Royal Society journal *Biology Letters* provides further evidence that random genetic mutations over millions of years may also play a powerful role.

Writing online Wednesday (Oct. 3), Florida and California scientists are the first to link the evolution of proteins — the organic compounds that determine the structure and function of living things — to a species' metabolic rate.

Across species from fish to mammals, they found that rates of protein evolution showed the same body size and temperature dependence as metabolic rate. Specifically, their mathematical model predicts that a 10-degree increase in temperature across species leads to about a 300 percent increase in the evolutionary rate of proteins, while a tenfold decrease in body size leads to about a 200 percent increase in evolutionary rates.

"It does suggest that if there were an evolutionary arms race between a small, hot animal and a cold, big animal, it's going to be awfully hard for the cold, big animal to keep up," said James F. Gillooly, an assistant professor of zoology in the University of Florida College of Liberal Arts and Sciences and a member of the UF Genetics Institute. "But really, what we are showing is that neutral processes, processes that do not depend on natural selection, are important in governing its evolution."

Natural selection, a concept first introduced by British naturalist Charles Darwin in 1859, is a cornerstone of biology that says evolution is driven by organisms passing along beneficial traits that help them survive and reproduce while weeding out unfavorable ones.

“We know evolution depends on the environment in which an animal lives,” Gillooly said. “And yet this study suggests that you can look at different species — and without knowing anything at all about their pressures to survive and reproduce in their respective environments — you can draw conclusions about their rates of protein evolution over millions of years. It’s pretty exciting.”

With collaborator Michael W. McCoy, Ph.D., a postdoctoral associate in UF’s department of zoology, scientists studied three cellular protein families from fish, amphibians, reptiles, birds and mammals — the only proteins for which sufficient data exist to perform the analyses.

“Generally, there are two schools of thought about what affects evolution,” said Andrew P. Allen, Ph.D., a researcher with the National Center for Ecological Analysis and Synthesis in Santa Barbara, Calif. “One says the environment dictates changes that occur in the genome and phenotype of a species, and the other says the DNA mutation rate drives these changes. Our findings suggest physiological processes that drive mutation rates are important.”

In a previous study, Gillooly and Allen determined how temperature controls rates of speciation — when animals and plants evolve into a new species. The latest research takes those findings to the genomic level.

“We’re not saying when this and that occur, an animal is going to grow a tail,” Allen said. “We can’t make these sorts of predictions, but this study suggests that we can perhaps predict how quickly an animal can evolve in the face of some environmental challenge. That is, we are defining

constraints on the overall rate of evolution."

Ultimately, the researchers found that rates of protein evolution are largely controlled by mutation rates, which in turn are strongly influenced by individual metabolic rates.

"There is an ongoing debate about what is driving the forces of evolution, and this is one of the clearest studies that say mutation is a driving force," said Dan Graur, Ph.D., the John and Rebecca Moores professor of biology and biochemistry at the University of Houston, who was not involved in the research. "If you want to put a catch phrase on it, it is not so much the survival of the fittest, but survival of the luckiest. The outcome is not determined by the 'fitness' of a particular trait, in terms of whether the trait affects an animal's ability to compete and survive.

"The database of proteins the researchers have used is limited, but at this time it is all there is to work with," Graur continued. "The sampling of the various species, however, is amazing. The paper reinforces the view that proteins evolve mainly by mutation, although it is possible that the evolution of 'important' traits is driven by positive Darwinian selection. Unfortunately, at present we do not know how to identify and quantify important traits."

Source: University of Florida