Reverse evolution in real-time

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Evolutionary biology tells us that replaying life's tape will not not look at all like the original. The outcome of evolution is contingent on everything that came before. Now, scientists at the Instituto Gulbenkian de Ciencia in Portugal, New York University and the University of California, Irvine, provide the first quantitative genetic evidence of why this is so.

In his book, Wonderful World, Stephen Jay Gould writes about an experiment of 'replaying life's tape', wherein one could go back in time, let the tape of life play again and see if 'the repetition looks at all like the original'. Evolutionary biology tells us that it wouldn't look the same - the outcome of evolution is contingent on everything that came before. Now, scientists at the Instituto Gulbenkian de Ciência (IGC) in Portugal, New York University and the University of California Irvine, provide the first quantitative genetic evidence of why this is so.

In this study, to be published online this week in the journal *Nature Genetics*, Henrique Teotónio and his colleagues recreated natural selection in real-time, in the laboratory (rather than based on inferences from fossil records or from comparing existing natural populations) and provide the first quantitative evidence for natural selection on so-called standing genetic variation - a process long thought to be operating in natural populations that reproduce sexually but which, until now, had never been demonstrated.

The researchers used laboratory-grown populations of fruit fly (*Drosophila melanogaster*), derived from an original group of flies, harvested from the wild back in 1975. These ancestral flies were grown in the laboratory, for two decades, under different environmental conditions, (such as starvation and longer life-cycles) so that each population was selected for specific characteristics. Henrique Teotónio and his colleagues placed these populations back in the ancestral environment, for 50 generations, to impose reverse evolution on the flies, and then looked at the genetic changes in certain areas of chromosome 3 of these flies.

Says Henrique, 'In 2001 we showed that evolution is reversible in as far as phenotypes are concerned, but even then, only to a point. Indeed, not all the characteristics evolved back to the ancestral state. Furthermore, some characteristics reverse-evolved rapidly, while others took longer. Reverse evolution seems to stop when the populations of flies achieve adaptation to the ancestral environment, which may not coincide with the ancestral state. In this study, we have shown that underlying these phenomena is the fact that, at the genetic level, convergence to the ancestral state is on the order of 50%, that is, on average, only half of the gene frequencies revert to the ancestral gene frequencies - evolution is contingent upon history at the genetic level too'.

These findings provide further insights into the basic understanding of how evolution and diversity are generated and maintained. On the one hand, it provides evidence for evolution happening through changes in the distribution of alleles in a population (so-called standing genetic variation), from generation to generation, rather than the appearance of mutations, from one generation to the next. On the other hand, as Henrique notes, 'It has implications for the definition of biodiversity: some of the 'reversed' flies may be phenotypically identical to the ancestral flies, but they are genetically different. How then do we define biodiversity?'

Source: Instituto Gulbenkian de Ciencia, Portugal