How evolution learns from past environments to adapt to new environments

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The evolution of novel characteristics within organisms can be enhanced when environments change in a systematic manner, according to a new study by Weizmann Institute researchers. Merav Parter, Nadav Kashtan and Uri Alon suggest that in environments that vary over time in a non-random way, evolution can learn the rules of the environment and develop organisms that can readily generate novel useful traits with only a few mutations. Details are published November 7 in the open-access journal *PLoS Computational Biology*.

The ability to generate novelty is one of the main mysteries in evolutionary theory. Recently, discoveries in evolution, genetics and developmental biology have been integrated to suggest that organisms have facilitated variation: a design whereby random genetic changes result in novel characteristics (phenotypes) that could be useful. For example, any one of many possible mutations within birds can result in a new beak shape appropriate for a new environment. This leaves the question of how facilitated variation spontaneously evolves.

In this study Parter, Kashtan and Alon began with the observation that environments in nature seemingly vary according to common rules or regularities. They proposed that organisms can learn how previous environments changed, and then use this information for their evolutionary advantage in the future. For example, if the available seeds tended to vary in size and hardness along history, then bird species might have learned to develop beaks with an easily tunable size and strength.

To check their hypothesis, the group employed computer simulations of evolution of simple computational 'organisms'. These organisms were evolved under two different scenarios: The first class evolved under unchanging environment, and the second class evolved under a systemically changing environment. The two scenarios yielded organisms with different designs. The organisms evolved under varying environments stored information about their history in their genome and developed a special modular design. Interestingly, they were able to generate novel useful phenotypes for a novel environment, as long as it shared the same rules with past environments.

The present study demonstrates the large effect the environment can have on the evolution of biological designs, and bring us another step forward towards understanding how the ability to generate useful novelties evolve.

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