Evolution on the table top

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Evolution has taken another step away from being dismissed as “a theory” in the classroom, thanks to a new paper published this week in the online open-access journal *PLoS Biology*. The research article, by Brian Paegel and Gerald Joyce of The Scripps Research Institute, California, documents the automation of evolution: they have produced a computer-controlled system that can drive the evolution of improved RNA enzymes—biological catalysts—without human input. In the future, this “evolution-machine” could feature in the classroom as well as the lab, allowing students to watch evolution happen in their biology lessons.

The evolution of molecules via scientific experiment is not new. The first RNA enzymes to be “evolved” in the lab were generated in the 1990s. But what is exciting about this work is that the process has been made automatic. Thus evolution is directed by a machine without requiring human intervention-other then providing the initial ingredients and switching the machine on.

As all students of Darwin know, evolution occurs when there is variation in a population; where some variants confer a survival or reproductive advantage to the individual, and where the basis for this advantage can be inherited. Finally, there must be a selection pressure—a reason that not all animals can survive or reproduce—such as a limited supply of food or a predator that must be avoided. These are the principles that the Paegel/Joyce system uses. The system begins with a population of RNA enzymes, which are the individuals that will evolve, and these enzymes vary slightly from each other. The enzymes are challenged to catalyse a reaction, and those that do catalyse it bind a “promoter” sequence to themselves in the process. Other enzymes in the machine (which act like part of the machine, rather than part of the experiment) cause any RNA enzyme bound to a promoter to be reproduced; therefore, enzymes that are good at reacting with the substrate become more numerous. This is analogous to those animals that are most successful being able to reproduce, both of which lead to the advantageous variation becoming more common.

In their system, Paegel and Joyce establish selection by having the evolution-machine reduce the availability of the reactants as time progresses. Therefore, the only enzymes to be reproduced are those that can bind a promoter when promoters are scarce. Any random mutation that allows an enzyme to bind a promoter more effectively is beneficial and will come to dominate the final population of enzymes. Throughout the process, the evolution-machine can propagate the reaction itself, because whenever the enzyme population size reaches a predetermined level, the machine removes a fraction of the population and replaces the starting chemicals needed for the reaction to continue.

By evolving the RNA enzyme according to this selection regime, the evolution-machine generated an enzyme that was better; it could work quickly with much lower concentrations of reactant then the ancestral enzymes could. The final enzyme at the end of Paegel and Joyce’s experiment had 11 mutations which together made it 90 times more efficient at using the starting ingredients.

This beautifully illustrates what about evolution is random and what is not. While the end point is predicted by the selection pressure—i.e., the decreasing concentration of ingredients determines that enzymes will evolve to cope with decreased concentration—the actual mutations that allow this are completely random and cannot be predicted at the outset—i.e., if you bought an “evolution machine” and ran the same experiment, your end product would be an enzyme that could cope with low concentrations too, but the mutations that it acquired to do this might be different.

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