Miniature worlds

A celebration of experimental evolution studies published in this journal.

In March of this year, an early sign of how the COVID-19 pandemic would affect universities around the world was the announcement by Richard Lenski that he was putting on hold his Long-Term Evolution Experiment (LTEE), the study that has been tracking 12 initially identical populations of *Escherichia coli* for over 70,000 generations. In the grand scheme of things this may seem trivial, especially as, compared with so much other research, it could very easily be placed in the freezer for subsequent resurrection. Indeed, this is not the first interruption in the experiment's 32-year history. But this versatility is a key strength of the burgeoning field of experimental evolution with microbes, and provides an opportunity to highlight some of the studies published in *Nature Ecology & Evolution* (a more comprehensive list can be found here).

For the 2009 Darwin bicentenary issue of *Nature*, Buckling et al.[1] wrote a review entitled 'The *Beagle* in a bottle', celebrating the first two decades of the field. They described how the ability to observe thousands of generations of evolution in real time, in controlled and simplified environments, was allowing tests of fundamental evolutionary theory, such as the rate and nature of adaptation, the evolution of diversity, and the role of social interactions. They also discussed the prospects of a detailed genomic understanding of evolution, although even as recently as 2009 that was largely confined to the future directions section.

Since then, there has been an explosion in genomics applied to experimental evolution, with the LTEE and many other experiments examined at whole-genome resolution, allowing a detailed understanding of the trajectory of clonal evolution (for example, here and here). Experimental evolution has also pushed further into other fundamental questions, such as coevolution (in this issue), epigenetics, the evolution of sex, the evolution of multicellularity, and the roles of gene loss and gain. It should be noted that experimental evolution is not exclusively about microbes (here, for example), but it is studies of microbes that benefit from the advantage of very large population size, rapid generation time and the ability to freeze and resurrect ancestors.

However, possibly one of the most exciting aspects of experimental evolution in the last decade or so is its ability to explore more applied questions. Perhaps the most obvious of these is antimicrobial resistance, given that antibiotics are used routinely as a tool in experimental microbiology. Experimental evolution studies have explored the genetic basis of resistance, the role of plasmids (for example, here and here) and their coevolution with host chromosomes in promoting resistance evolution, the role of ecological interactions in maintaining resistant and susceptible populations, and the potential of phages as a means of control. A less obvious medical application of experimental evolution is in cancer, where direct experiments can be carried out on cancer cell lines under drug treatments, and studies of clonal evolution in other organisms can be used to make indirect predictions.

Experimental evolution has also started to play a role on global change research, in particular in looking at the response of phytoplankton to warming and acidification, in an attempt to understand the large-scale ecological and biogeochemical consequences of such stressors. Experimental evolution can also be used to predict community responses to pollution, and to explore the role of gene transfer in contaminated soil microbial communities.

None of this is to say that experimental evolution does not have its limitations. The artificial, and predominantly prokaryotic nature of the studies means caution is required extrapolating to complex multicellular communities. Nevertheless, the ability to examine large populations over thousands of generations is rarely mirrored in natural settings, and when interpreted with the appropriate caution, experimental evolution can be a powerful exploratory tool, both for fundamental and applied questions. We look forward to a rapid restart to experimental evolution research as laboratories emerge from lockdown. ❐

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References

1. Buckling, A., Maclean, R. C., Brockhurst, M. A. & Colegrave, N. *Nature* **457**, 824–829 (2009).