



Peer Community In Evolutionary Biology

A poster child for experimental evolution

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Baym M, Lieberman TD, Kelsic ED, Chait R, Gross R, Yelin I, Kishony R (2016) Spatiotemporal microbial evolution on antibiotic landscapes. *bioRxiv*, ver. 1, peer-reviewed and recommended by Peer Community in Evolutionary Biology.

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Evolution is usually studied via two distinct approaches: by inferring evolutionary processes from relatedness patterns among living species or by observing evolution in action in the laboratory or field. A recent study by Baym and colleagues in *Science* [1] has now combined these approaches by taking advantage of the pattern left behind by spatially evolving bacterial populations. Evolution is often considered too slow to see, and can only be inferred by studying patterns of relatedness using phylogenetic trees. Increasingly, however, researchers are moving nature into the lab and watching as evolution unfolds under their noses. The field of experimental evolution follows evolutionary change in the laboratory over 10s to 1000s of generations, yielding insights into bacterial, viral, plant, or fly evolution (among many other species) that are simply not possible in the field. Yet, as powerful as experimental evolution is, it lacks a posterchild. There is no Galapagos finch radiation, nor a stunning series of cichlids to showcase to our students to pique their interests. Let's face it, *E. coli* is no stickleback! And while practitioners of experimental evolution can explain the virtues of examining 60,000 generations of bacterial evolution in action, appreciating this nevertheless requires a level of insight and imagination that often eludes students, who need to see "it" to get it. Enter MEGA, an idea and a film that could become the new face of experimental evolution. It replaces big numbers of generations or images of scientists, with an actual picture of the scientific result. MEGA, or Microbial Evolution and Growth Arena, is essentially an enormous petri dish and is the brainchild of Michael Baym, Tami Lieberman and their colleagues in Roy Kishony's lab at Technion Israel Institute of Technology and Harvard Medical School. The idea of MEGA is to allow bacteria to swim over a spatially defined landscape while adapting to the local conditions, in this case antibiotics. When bacteria are inoculated onto one end of the plate they consume resources while swarming forward from the plate edge. In a few days, the bacteria grow into an area with antibiotics to which they are susceptible. This stops growth until a mutation arises that permits the bacteria to jump this hurdle, after which growth proceeds until the next hurdle of a 10-fold higher antibiotic concentration, and so on. By this simple approach, Baym *et al.* [1] evolved *E. coli* that were nearly 105-fold more resistant

to two different antibiotics in just over 10 days. In addition, they identified the mutations that were required for these changes, showed that mutations conferring smaller benefits were required before bacteria could evolve maximal resistance, observed changes to the mutation rate, and demonstrated the importance of spatial structure in constraining adaptation. For one thing, the rate of resistance evolution is impressive, and also quite scary given the mounting threat of antibiotic-resistant pathogens. However, MEGA also offers a uniquely visual insight into evolutionary change. By taking successive images of the MEGA plate, the group was able to watch the bacteria move, get trapped because of their susceptibility to the antibiotic, and then get past these traps as new mutations emerged that increased resistance. Each transition showcases evolution in real time. In addition, by leaving a spatial pattern of evolutionary steps behind, the MEGA plate offers unique opportunities to thoroughly investigate these steps when the experiment is finished. For instance, subsequent steps in mutational pathways can be characterized, but also their effects on fitness can be quantified in situ by measuring changes in survival and reproduction. This new method is undoubtedly a boon to the field of experimental evolution and offers endless opportunities for experimental elaboration. Perhaps of equal importance, MEGA is a tool that is portable to the classroom and to the public at large. Don't believe in evolution? Watch this. You only have time for a short internship or lab practical? No problem. Don't worry much about antibiotic resistance? Check this out. Like the best experimental tools, MEGA is simple but allows for complicated insights. And even if it is less charismatic than a finch, it still allows for the kinds of "gee-whiz" insights that will get students hooked on evolutionary biology.

References:

- [1] Baym M, Lieberman TD, Kelsic ED, Chait R, Gross R, Yelin I, Kishony R. 2016. Spatiotemporal microbial evolution on antibiotic landscapes. *Science* 353:1147-1151. doi: [10.1126/science.aag0822](<https://doi.org/10.1126/science.aag0822>)

Reviews

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