New insights revealed in the evolution of community-level heredity

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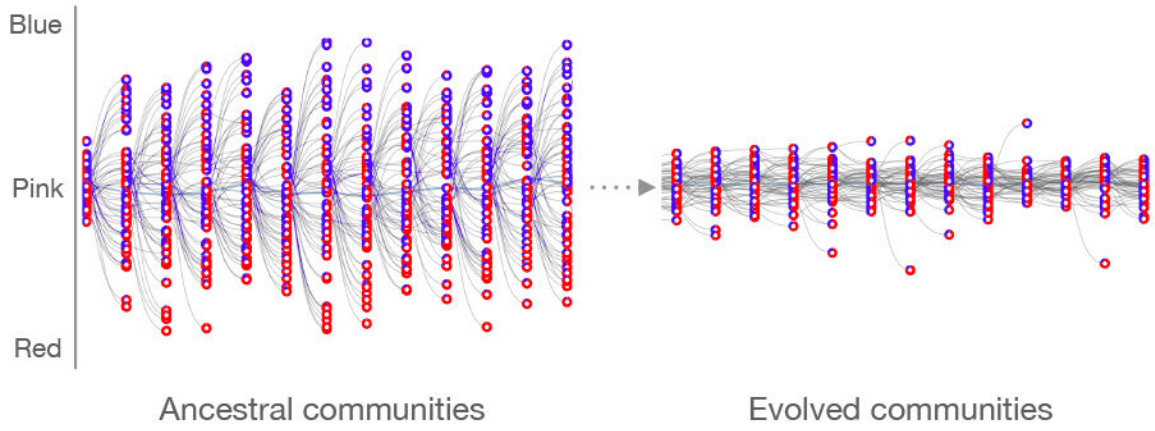

Communities founded with an equal ratio of red-to-blue cells are assessed after a round of cell growth. Communities far from the optimal pink colour (1:1 ratio) are eliminated, whereas those close to the optimum are selected to leave offspring communities. Stochastic effects dominate early-stage evolution with lack of fidelity between parent and offspring resulting in high levels of community death. After a period of selection "developmental correction" evolves, increasing the correspondence between parental and offspring communities. Credit: Paul B Rainey

What would happen if a selection experiment was performed on thousands of communities of microbes based on some community-level

function? Researchers from ESPCI Paris-PSL, College de France, and ENS-PSL used a theoretical approach to show that not only is this feasible, but that community-level heredity can arise from the evolution of interactions among microbes. The results have been published in *eLife*.

Heredity is a fundamental requirement for Darwinian evolution, but its origins are obscure. A team of scientists from CBI, College de France, and IBENS show that interactions among component parts can evolve to the point where the material basis of heredity becomes established.

The team modeled the evolution of microbial cells nested within a set of evolving microbial communities. Central to the work were simulations involving thousands of communities that were either eliminated or allowed to reproduce depending on expression of a given community-level phenotype.

Founding communities were comprised of microbial cells that did not interact and thus the relationship between parent communities and their immediate offspring communities was arbitrary and determined by stochastic effects alone. However, after a period of community-level selection, interactions among cells evolved that overwhelmed stochastic sampling effects resulting in communities capable of producing offspring communities with high fidelity.

"What is remarkable is that communities evolve the capacity to leave offspring copies, where offspring copies closely resemble the parental communities " says Paul Rainey, author of the study. "The basis is akin to a developmental process that arises from density-dependent interactions among microbial cells."

The work establishes a firm theoretical basis for many applications in biotechnology, medicine, and agriculture, where new functions, new

chemistries and even new organisms stand to emerge from selection on communities of microbes. The work also tackles issues that underpin the evolution of biological complexity, from the evolution of the first self-replicating chemistries, to the evolution of symbioses, such as those that gave rise to eukaryotic cells.

The research was supported by OCAV, the origins of life initiative from PSL University. An actual "evolution machine" built by Jérôme Bibette and his CBI team is now at the beta-testing stage. The machine allows experimental exploration of central ideas and will be used to build new kinds of microbial life for a broad range of applications.

More information: Guilhem Doulcier et al. Eco-evolutionary dynamics of nested Darwinian populations and the emergence of community-level heredity, *eLife* (2020). DOI: 10.7554/eLife.53433

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