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Selective sweeps in growing microbial colonies

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Evolutionary experiments with microbes are a powerful tool to study mutations and natural selection. These experiments, however, are often limited to the well-mixed environments of a test tube or a chemostat. Since spatial organization can significantly affect evolutionary dynamics, the need is growing for evolutionary experiments in spatially structured environments. The surface of a Petri dish provides such an environment, but a more detailed understanding of microbial growth on Petri dishes is necessary to interpret such experiments. We formulate a simple deterministic reaction-diffusion model, which successfully predicts the spatial patterns created by two competing species during colony expansion. We also derive the shape of these patterns analytically without relying on microscopic details of the model. In particular, we find that the relative fitness of two microbial strains can be estimated from the logarithmic spirals created by selective sweeps. The theory is tested with strains of the budding yeast Saccharomyces cerevisiae, for spatial competitions with different initial conditions and for a range of relative fitnesses. The reaction-diffusion model also connects the microscopic parameters like growth rates and diffusion constants with macroscopic spatial patterns and predicts the relationship between fitness in liquid cultures and on Petri dishes, which we confirmed experimentally. Spatial sector patterns therefore provide an alternative fitness assay to the commonly used liquid culture fitness assays.

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