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Budding yeast star in their own biofilm

Study describes the multicellular, differentiated structures formed by wild strains of *S. cerevisiae*.

Laboratory strains of *Saccharomyces cerevisiae* enjoy a much more comfortable life than their undomesticated relatives. Váchová et al. detail the complex colonies that wild strains of budding yeast form in order to survive the hostile conditions of their natural environment (1).

Most microorganisms can form highly organized multicellular structures known as biofilms. These aggregates attach to surfaces and help protect the population from external threats such as chemicals or a host's immune system (2). Although domesticated strains of *S. cerevisiae* primarily form the simple, flat colonies familiar to scientists around the world, budding yeast can form much more complex, biofilm-like colonies in the wild (3). Yet little is known about the development and function of these structures, in part because of the difficulties associated with looking inside the colonies as they form.

Zdena Palková, from Charles University in Prague, the Czech Republic, and her colleagues decided to overcome these problems using two-photon microscopy (4). "We wanted to know what the internal structure of these colonies looks like and to investigate the mechanisms involved in organization and protection," Palková explains.

Váchová et al. followed the development of a wild *S. cerevisiae* strain from a single cell plated on agar into a complex biofilm-like colony (1). Over several days, the yeast formed an intricate, three-dimensional structure with an internal cavity. Elongated cells at the base of the colony formed extended filaments that the researchers termed pseudohyphae, which projected into the agar to keep the colony firmly anchored to its substrate. Meanwhile, oval cells on the upper, air-exposed surface of the colony formed multiple ridges, lending the colony a wrinkled appearance.

Individual cells within the colonies were connected to each other by long fibers, which were absent from yeast colonies lacking the cell wall adhesion protein Flo11p. These fibrous connections may be required for the 3D organization of yeast colonies, because Flo11p-deficient strains fail to form ordered biofilm-like structures (5).

Váchová et al. then found that cells within the colonies are functionally, as well as structurally, diverse. "There are specific cells with specific functions in specific places," says Palková, comparing the yeast biofilm to differentiated, multicellular organisms. For example, while cells in the colony interior continue to divide, cells near the upper surface exit the cell cycle after a few days of growth, forming a layer of stationary cells that may better withstand environmental stresses.

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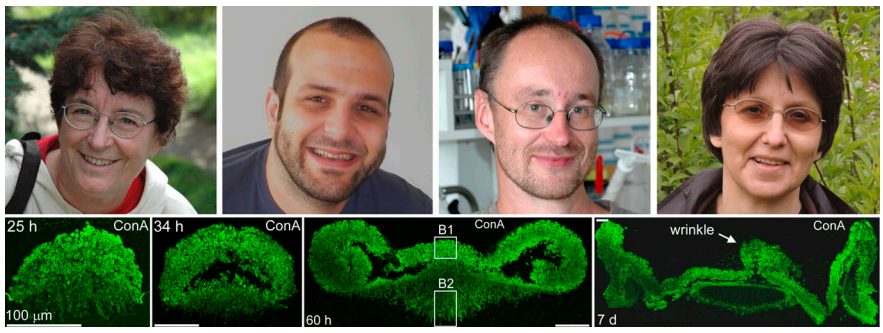
The researchers found two other specializations that may protect the developing yeast colony. The outer layers of cells (both air- and agar-exposed) express the multidrug resistance transporters Pdr5p and Snq2p. Wild-type yeast could export a fluorescent small molecule out of their surface layers, but yeast colonies lacking Pdr5p and Snq2p were unable to exclude the dye.

In addition, cells in the colony interior may protect themselves by producing a selectively permeable extracellular matrix (a property shared by many biofilm-forming yeast species but not by laboratory strains of *S. cerevisiae*). Palková and colleagues don't yet know the constitution of this matrix, but galactose molecules and copper ions added to the underlying agar were unable to diffuse into the colony interior. The low permeability of the extracellular matrix may protect the continuously dividing internal yeast cells from harmful, antifungal agents.

Wild strains of *S. cerevisiae* therefore form complex, differentiated colonies that are very similar to biofilms in terms of their organization and protective mechanisms. Palková and first author Libuše Váchová hope that their groups' studies will establish budding yeast as a model for investigating the conserved features of biofilm form and function. "Our major goal is to find out how these processes are regulated," says Palková. "Why do cells in a particular position start to do what they do? We'd also like to understand the composition of the extracellular matrix and find compounds that disrupt this barrier, which could be very important medically."

Focal Point



PHOTOS COURTESY OF THE AUTHORS

(Top row, left to right) Libuše Váchová, Vratislav Šťovíček, Otakar Hlaváček, Zdena Palková, and colleagues (not pictured) analyze the complex, biofilm-like colonies formed by non-domesticated strains of *S. cerevisiae*. Vertical cross sections through developing colonies show their architecture at (bottom row, left to right) 25 hours, 34 hours, 60 hours, and 7 days. Cells in distinct regions are functionally specialized to protect the colonies from environmental insults. Cells in the outer layers express multidrug resistance-type pumps, whereas internal cells produce a selectively permeable extracellular matrix.

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4. Váchová, L., et al. 2009. *Environ. Microbiol.* 11:1866–1877.
5. Vopálenská, I., et al. 2010. *Environ. Microbiol.* 12:264–277.