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Is this how simple life got complicated?

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A new study has created an analog of what researchers think the first multicellular cooperation might have looked like, showing that yeast cells—in an environment that requires them to work for their food—grow and reproduce better in multicellular clumps than singly.

A team of researchers, led by Harvard professor Andrew Murray, found that cells of brewer's yeast that clumped together were able more effectively to manipulate and absorb sugars in their environment than were similar cells that lived singly. The experiments showed that in environments where the yeast's sugar food source is dilute and the number of cells is small, the ability to clump together allowed cells that otherwise would have remained hungry and static to grow and divide.

The work, published August 9 in the online, open access journal *PLoS Biology*, used the yeast Saccharomyces cerevisiae, which is commonly used in brewing and bread-making and has long been used by scientists as a model organism for understanding single-celled life. Murray and colleagues devised a series of experiments that presented two problems for the yeast cells to solve if they were to take in enough food to grow and divide: the first was how to change their food from an unusable form to a usable form; the second was how to actually take in this food.

The researchers put the yeast in a solution of sucrose—plain old table sugar—which is composed of two simpler sugars, glucose and fructose. Yeast lives on sugar, but the sucrose can't get through the membrane that surrounds the cell. So the yeast makes an enzyme called invertase to chop the sucrose into glucose and fructose, each of which can enter the cell using gate-keeping molecules, called transporters, that form part of the membrane.

The second problem was how to get the glucose and fructose from the place where they were split apart by invertase to the transporters in the cell membrane. The only way to bridge the gap is through diffusion, an inefficient process. Researchers calculated that once a cell makes invertase and chops the larger sugar down to usable bits, only one sugar molecule in 100 would be captured by the cell that made it.

They also calculated that, working alone, a single yeast cell in a dilute solution of sucrose would never take in enough glucose and fructose to be able to grow and divide. But by cooperating, clumps of yeast in that same solution might have a chance. With several cells in proximity, all releasing invertase to create smaller sugars, these cooperating yeast cells would increase the density of those sugars near the clump, increasing the chances that each cell could take in enough to grow and divide. Sure enough, when the researchers tested these hypotheses on two strains of yeast, they found that the strain which clumped cells together was growing and dividing, while the yeast cells living alone were not.

Murray said the work offers one explanation as to why single-celled organisms might have initially banded together deep in the history of life, although it's impossible to prove conclusively that this is what happened. "Because there is an advantage to sticking together under these circumstances, and because we know that lots of single-celled organisms make enzymes to liberate goods from their environment, this may be the evolutionary force that led to multicellularity," Murray said. Although, he continued, "short of inventing time travel and going back several billion years to see if this is how it happened…this is going to remain speculation."

More information: "Sucrose Utilization in Budding Yeast as a Model

for the Origin of Undifferentiated Multicellularity." *PLoS Biol* 9(8): e1001122. doi:10.1371/journal.pbio.1001122

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