

Science Education Collection

Yeast Reproduction

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Abstract

Saccharomyces cerevisiae is a species of yeast that is an extremely valuable model organism. Importantly, *S. cerevisiae* is a unicellular eukaryote that undergoes many of the same biological processes as humans. This video provides an introduction to the yeast cell cycle, and explains how *S. cerevisiae* reproduces both asexually and sexually. Yeast reproduce asexually through a process known as budding. In contrast, yeast sometimes participate in sexual reproduction, which is important because it introduces genetic variation to a population. During environmentally stressful conditions, *S. cerevisiae* will undergo meiosis and form haploid spores that are released when environmental conditions improve. During sexual reproduction, these haploid spores fuse, ultimately forming a diploid zygote. In the lab, yeast can be genetically manipulated to further understand the genetic regulation of the cell cycle, reproduction, aging, and development. Therefore, scientists study the reproduction of yeast to gain insight into processes that are important in human biology.

Transcript

Despite being a simple unicellular eukaryote, *Saccharomyces cerevisiae* serves as a valuable model organism because its cellular processes, such as the cell cycle, resemble those found in higher order eukaryotes, like us. In the yeast cell cycle, cell growth and cell division are tightly linked and are dependent on factors such as nutrient concentration. Depending on environmental cues, yeast can undergo asexual or sexual reproduction to produce new cells. This video will give you an overview on the yeast cell cycle and the different forms of reproduction in *S. cerevisiae*.

Let's quickly brush up on our knowledge of the cell cycle. Two major phases exist, Interphase, which is comprised of G1, S, and G2 sub-phases; and M phase, or Mitosis. As you know, mitosis is an important component of cell division, and yeast are peculiar in that they divide asymmetrically via a mechanism for asexual reproduction, known as budding.

In the G1 phase, cells commit to the cell cycle at the START point. Buds appear during the S phase and continue to grow on through the rest of the cell cycle, including mitosis. When cytokinesis is complete, unequal division of the cytoplasm yields a smaller daughter cell. Unfortunately for the mother cell, visible scarring occurs at the site of cell division. Fortunately for scientists however, fluorescent labeling of the cell wall component chitin allows researchers to examine the budding pattern of a yeast cell and estimate how many times it has divided.

A newly formed cell will grow in G1 phase, in the presence of nutrients, until certain conditions are met and a cell cycle checkpoint, or restriction point called START is reached. Once cells pass through START, they are committed to the remainder of the cell cycle and will divide again. Before this checkpoint is reached, however, yeast can undergo meiosis and subsequent sexual reproduction.

Now why should a unicellular eukaryote like yeast need to undergo sexual reproduction?

As you may have already learned, sexual reproduction is a way to introduce variation in a population of organisms, which promotes survival.

The type of yeast that mate are haploids, which contain one copy of the genome, like egg or sperm cells. There are two haploid mating types, Mat a and Mat alpha, and these cells can bud and reproduce asexually, like diploid yeast.

Each of these mating types release pheromones. Mat a releases the a factor and Mat alpha releases the alpha factor. The pheromones are detected by the opposite mating types and cause the haploid yeast to change shape by elongating and entering the shmoo phase.

During this phase, two haploids continue to grow towards each other until achieving cell-cell contact. Subsequent cell-to-cell and nuclear fusion results in the formation of the zygote. The nascent zygote then re-enters the mitotic cell cycle, giving rise to its first diploid bud. Zygotes will appear dumbbell shaped cells, either with or without a bud.

You might be wondering how haploids are produced in the first place. The answer is simple: meiosis. You probably already know that, following an initial chromosomal duplication, meiosis

results in daughter cells with half the number of chromosomes as the parent cell. When yeast are under environmentally stressful conditions a form of meiosis takes place, known as sporulation.

During sporulation, haploid spores are produced for each mating type and are contained in a tough membranous structure called an ascus, as indicated here with yellow circles. When environmental conditions improve, spores are released from the ascus. From there, they further develop into Mat a and Mat alpha haploid cells and go through the sexual reproduction cycle once again.

Now that you are familiar with yeast reproduction, let's take a look and see how this process can be applied for further studies.

Understanding yeast reproduction is integral in genetic experiments, for example, generating yeast strains with multiple mutations. In this video, you can see the mixing of two different haploid strains, Mat a and Mat alpha, on an agar plate, and the subsequent incubation to allow for mating and diploid formation. They are then replica plated onto selective media that will only permit diploid growth. The diploids can then be sporulated in nutrient deficient media, the resulting haploid spores dissected with a micromanipulator, and seeded onto an agar plate in a matrix pattern. The haploid genotypes can be confirmed by PCR or growth on selective media.

Aging studies can also be carried out by examining the replicative lifespan of yeast cells. The replicative life span is the number of buddings a cell goes through in its lifetime. A single yeast cell can produce 30 or so buds before dying. Here, you can see that a micromanipulator is used to separate a daughter cell from the mother cell in order to analyze the yeast life span over time. The raw data produced by a replicative lifespan experiment is a list of numbers corresponding to daughter cells produced by each mother cell at each age point.

The development of cell morphology as a function of cellular processes, such as protein concentration, can be studied in budding yeast. Over here you see the preparation of cells for microcopy to visualize specific phenotype-specific defects. In this time-lapse video, multi- buds form, indicating that cells fail to separate from each other, suggesting a defect in cell division.

You've just watched JoVE's introduction to reproduction of *Saccharomyces cerevisiae*. In this video, we talked about the yeast cell cycle and touched base on the asexual and sexual reproduction life cycles of this specie. Thanks for watching, and don't forget about your shmoo!