# Scientific Literacy Essay

There are few organisms as critical to new scientific discovery as the single cell, eukaryotic organism known as yeast. This important organism not only is critical for making bread and beer but also helps scientist discover new information about cellular functions and reproduction. There are two traditional yeast types studied in cell biology which are *Saccharomyces cerevisiae* and *Schizosaccharomyces pombe*. The main difference in these two types of yeast is that *Saccharomyces cerevisiae* reproduce by budding while *Schizosaccharomyces pombe* reproduce by binary fission. Both reproductive processes differ from normal mitosis in that they produce another organism while normal mitosis is used for the growth of an individual organism. Binary fission and budding are both modes of asexual reproduction that result in offspring that are genetically identical to the parent (Samanthi, 2019). These processes both undergo mitosis and cytokinesis. There are many distinct differences when examining these methods of reproduction. Binary fission results in the parent being unidentifiable due to the symmetric division of the parent into two equally sized daughters, whereas in budding the parent organism remains the same after the asymmetric division and detaching the smaller daughter. Another difference is that binary fission is a natural process, and budding can be induced artificially (Zaky, 2014). In the process of budding, there is an outgrowth from the parent which produces a bud that detaches resulting in a daughter that grows until it reaches the parent's size, while there is no outgrowth or bud formation during binary fission. In binary fission the cell becomes cylindrical as it elongates until it splits proportionally in half. Binary fission is common in prokaryotes (bacteria and archaea) while budding is found in eukaryotic organisms (fungi and plants) (Isaksson, 2021).

There are four broad genus types of marine yeast, and they include *Candida, Cryptococcus, Debaryomyces,* and *Rhodotorula*. *Candida* reproduces through budding, but it is possible for some species to undergo sexual reproduction. It is a round or oval yeast cell. It is considered a pathogen and colonizer found in leaves, water, and soil. Genus contains one hundred and fifty-four species. Colonies characterized as cream to yellowish in color and grow rapidly (Dr. Fungus, 2017). *Cryptococcus* is an encapsulated yeast. They are oval with a polysaccharide cap. Reproduce by budding but can also reproduce sexually through spores. Many members of this genus contain hyphae which is used during budding. Genus contains thirty-seven species. Colonies characterized as white, cream or tan in appearance and experience a very rapid growth rate. All species lack fermentative capacity (Hardy Diagnostics, 2016). *Debaryomyces* is an ascomycetous (spore shooters) genus. Ascomycetes produce sexual structures in which spores are formed. It can reproduce through sexual reproduction by conjugation between a cell and its bud or between independent cells. Can also undergo asexual reproduction by multilateral budding. Pseudohyphae are uncommon or insufficiently developed in this genus. Genus contains fifteen species, and some can act as a fermenter (Praphailong, 2004). *Rhodotorula* produces pink to red colonies and have a rapid growth rate. They lack pseudohyphae and hyphae. Reproduces asexually by multilateral budding and binary fission. Found in air, soil, seawater, plants, and dairy products. Sphere or oval in appearance. Generalized as a mucous appearance due to capsule formation like *Cryptococcus*. Genus contains thirty-seven species and cannot ferment carbohydrates (Yeeh, 2004).

There are four species of marine-derived black yeast that were studied in the experiment. These yeasts were *Hortaea werneckii*, *Knufia petricola*, *Aureobasidium pullulans*, and *Phaeotheca salicorniae*. The scientist conducted tests to determine how the cell cycles of each

species differentiated and recorded their results. *Hortaea werneckii* (730 min) and *Knufia petricola* (499 min) had relatively long cell cycles compared to *Aureobasidium pullulans* (159.5 min). *Aureobasidium pullulans* have a shorter cell cycle due to only a single bud forming during each cell cycle. The timing of first bud formation was differentiated when *Hortaea werneckii* (253 min) took on almost twice the amount of time of the similar other species Knufia petricola (110 min) and *Aureobasidium pullulans* (135 min). *Phaeotheca salicornia*e did not have a cell cycle duration or time to first bud because it reproduced differently in the form of a meristematic colony. In the colony, some cells change to hyphae producing cells and then other that are inside the matrix continue to divide into yeast cells. The hyphae grow, and the yeast continue to divide meristematically. This cell division and growth is different from the others so it cannot be compared with numerical data. Except for *Aureobasidium pullulans*, the parents, and daughters of all the yeast species each have a single cell nucleus. *Aureobasidium pullulans* have the ability for the mother cell to produce multiple nuclei and then transfer one to each of their budding daughters. There were between one and seven nuclei observed in the mother cell at a single point in time. When compared directly, the growth patterns of the yeasts are unique, but shared many common features. *Phaeotheca salicorniae* looks like *Hortaea werneckii* in the early stages of its growth pattern due to both making septum, which forms clusters of cells. *Hortaea werneckii* then alternates between budding and septation, unlike *Phaeotheca salicorniae,* which begins to transition into other cell types and undergo hyphae growth, which makes it look like *Knufia petricola*, whose growth pattern resembles clusters with linear protrusions. The hyphae can produce cells like the original yeast cells. However, *Knufia petricola* does not produce any hyphae, but instead produces linear chains of spherical cells. This chain growth continues until it eventually changes direction or if a parent cell budded multiple times, it would start a chain in a

new direction. *Aureobasidium pullulans* is unique because it can produce multiple buds from the same location at the same time. These buds are generally much smaller than their parent. Each yeast also has a unique cell shape. *Hortaea werneckii* is in the form of a pill, while *Knufia petricola* is like spherical beads. *Aureobasidium pullulans* looks like a lime, while *Phaeotheca salicorniae* has a distinctive cheese wedge shaped (Mitchinson-Field, 2019).

All the yeast in this experiment were black yeast which means that they contained a melanized and thick cell well. These specialized cell walls allow them to survive in extreme environmental conditions such as in contaminated marine systems, which would kill most other forms of yeast (Kirchhoff, 2017). Also, unlike the yeast previously examined such as *Saccharomyces cerevisiae and Schizosaccharomyces pombe* the black yeast *Hortaea werneckii* switches between budding and binary fission. *Hortaea werneckii* is also different from traditional binary fission because no separation of daughter cells is observed after the septum is formed. *Saccharomyces cerevisiae* produces only a single bud, and the mother only has one nucleus, but *Aureobasidium pullulans* the mother cell could produce multiple buds and nuclei. Contrasted with traditional yeast, the black yeast exhibit unconventional cell division cycles and have higher plasticity in terms of physical properties (Mitchinson-Field, 2019).

| | H. Werneckii | K. petricola | A. pullulans | P. salicorniae |
|---|---|---|---|---|
| **Cell Cycle Duration** | 730 min | 499 min | 159.5 min | N/A |
| **Time to first bud** | 253 min | 110 min | 135 min | N/A |
| **# Nuclei** | Mother and Daughter: 1 | Mother and Daughter: 1 | Mother cells: Multiple (1-7)<br>Buds: 1 | Mother and Daughter: 1 |
| **Growth Pattern** | Budding and Septation. Forms a division septum. Septum splits cell in half. | Patterned/linear spherical budding. Elongation linear length of Cells. | Multiple Budding | Hyphal growth/ Forms a division septum. Triangle shape of septum. |
| **Cell Shape** | Pill-shaped | Spherical beads | Lime Shaped | Wedge-shaped |
| **Color** | Light Brown/Black | Black | Yellow | Orange/Black |

**Table 1**: Cell Cycle Observations for Marine Yeast (Mitchinson Field, 2019)

**Reference List**

Samanthi. (2019). Difference Between Binary Fission and Budding. Difference Between, https://www.differencebetween.com/difference-between-binary-fission-and-vs-budding/.

Zaky, Abdelrahman S., Tucker, Gregory A., Daw, Zakaria Y., & Du, Chenyu. (2014). Marine Yeast Isolation and Industrial Application. FEMS Yeast Research, National Center for Biotechnology Information, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4262001/.

Isaksson, Hanna, Conlin, Peter L., Kerr, Ben, Ratcliff, William C., & Libby, Eric. (2021). The Consequences of Budding Versus Binary Fission on Adaptation and Aging in Primitive Multicellularity. Nation Center for Biotechnology Information, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8145350/.

Dr. Fungus (2017). Candida Species. Dr. Fungus, https://drfungus.org/knowledge-base/candida-species/.

Hardy Diagnostics (2016). Description of the Genus – Cryptococcus. Hardy Diagnostics, https://catalog.hardydiagnostics.com/cp_prod/Content/hugo/Crytococcus.html.

Praphailong, W., & Fleet, G. H. (2004). Debaryomyces. Encyclopedia of Food Microbiology. Science Direct, https://www.sciencedirect.com/science/article/pii/B012227070300430X.

Yeeh, Yeehn. (2004). Rhodotorula. Encyclopedia of Food Microbiology. https://www.sciencedirect.com/science/article/pii/B0122270703013404.

Mitchison-Field, L.M.Y., Vargas-Muniz, J.M., Stormo, B.M., Vogt, E.J.D., Van Dierdonck, S., Pelletier, J.F., Ehrlich, C., Lew, D.J., Field, C.M., and Gladfelter, A.S. (2019). Unconventional Cell Division Cycles from Marine-Derived Yeasts. Curr Biol 29, 3439-3456

Kirchhoff, Lisa, Maike Olsowski, Katrin Zilmans, Silke Dittmer, Gerhard Haase, Ludwig Sedlacek, Eike Steinmann, Jan Buer, Peter-Michael Rath, and Joerg Steinmann. (2017). Biofilm Formation of the Black Yeast-like Fungus Exophiala Dermatitidis and Its Susceptibility to Antiinfective Agents. Nature News, Nature Publishing Group, https://www.nature.com/articles/srep42886.