Marine Yeasts

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Background

Yeast cells have two different ways to divide. Although yeast cells do not divide as metazoa do, their division is still considered to be processes of mitosis. Yeast cells divide through budding and/ or through fission. An "and/or" was added seeing as some yeast cells use both budding and fission, and are not always uniform in their mitosis. Budding and fission are two very different processes, however, neither process requires the nuclear envelope to break down. Budding is considered to be an asymmetric process, as it produces a small bud, identical to the mother cell, except smaller. Fission divides symmetrically with two identical daughter cells. Both processes use a certain landmark or structure to decide where division will occur. Budding typically divides at the same place it has divided before. On the other hand, fission divides based on the location of the nucleus. Both budding and fission each have a distinct cycle at which these landmarks are decided. The position of the bud is confirmed in the late G1 cycle, whereas the fission division site is determined during the late G2 cycle. (Allard, 2019; Humphrey T., 2005; Balasubramanian, 2004)

The four main yeast genus types are Candida, Cryptococcus, Debaryomyces, and Rhodotorula. All of these types use budding division to divide. Candida has proven to be a fierce survivor when it comes to time and conditions. This large round and primarily white yeast is a common inhabitant of the gastrointestinal flora in humans and other animals. It's adaptability shines through as it is able to inhabit every single type of human tissue or organ. This allows it to be one of the most common cells to produce infection. Although it has been many millenia, candida is distantly related to the *Saccharomyces cerevisiae*. (Wikipedia contributors, 2021a) The two share key features. They are still, however, very different. (WikiDoc contributors, 2021; Hernday, 2010)

Cryptococcus prefer to live mainly in soil. Due to their affinity for living in the ground, they have been able to have an impressive range of diversity. They have specialized adaptations for living in the soil, such as being covered in a gel-like material. This material is made of glycoproteins and is used for absorbing nutrients found in the soil. We pay attention to cryptococcus, as several of its species cause extreme infections in humans such as *C. neoformans* and *C. gattii*. (Wikipedia contributors, 2021b)

Debaryomyces, like cryptococcus, are found in soil. They are also inhabitants of several other mediums such as food and water. Like the other genuses of yeast being considered in this paper, debaryomyces have certain species that are closely followed and studied. *Debaryomyces hansenii*, for example, is closely studied as it is found frequently in food. As mentioned previously, debaryomyces typically use budding to reproduce, specifically multilateral budding. Multilateral budding occurs when a cell can produce a bud anywhere on the cell. (Wrent, 1999; Anon, 2010)

Rhodotorula is much like the other genuses in that it is found almost everywhere: soil, water, vegetables, etc. This is the first genus of yeast, so far, that has been confirmed to be found in fish guts. Appearing in red or yellow colonies, Rhodotorula are likely to be found in relatively moist environments. (Yeeh, 1999; Albertyn, 2014)

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H. werneckii are pill-like and, like the other species, are very hardy and tend to have a very high salt tolerance. When they begin to divide, a septum forms dividing the cell in half. What at first appears to be fission, turns into budding. Although a septum does form, rather than dividing, the cell proceeds to produce buds rather than splitting. However, this particular species is impressive due to its ability to switch between budding and fission. While it does produce buds, it will switch between the two modes of division, dividing where the septum was created. *H. werneckii* switch between the two modes regularly, perhaps to have an advantage when it comes to changing environmental factors. Cell division in this species does not appear to have any particular pattern, aside from producing septums and buds. As the bud forms, DNA enters the new cell or bud. *H. werneckii* appear to have a single nucleus.

K. petricola are noted for being extraordinary due to their appearance of being almost perfectly spherical. The reason for this being so noteworthy is because they have the ability to produce linear budding cells. Their spherical shape should make it harder for them to produce lines, however, the buds seem to start forming almost exactly opposite to the last budsite, allowing for lines to form. It would be easy to say that these yeast cells have a tendency to follow a pattern. They also have the ability to branch off of these lines. Their growth rate is the same no matter the direction the buds are heading. Their growth is comparable to the snowflake yeast in *S. cerevisiae*. Snowflake yeast, however, forms from a mutation. Like *H. werneckii, K. petricola* are noted to have DNA transferred after the bud has already formed and to only have one nucleus.

A. pullulans, a yeast known to be able to produce an enzyme that is able to degrade plastic, closely resembles a lemon that produces a bunch of little oblong lemons from a single site, up to six at a time. The cell division of *A. pullulans* is very interesting to watch as it is simultaneous production of several cells. It does not appear to follow a pattern, just a continuous flow of budding cells from the same site. DNA seems to enter the cell before the bud forms. The DNA transfer appears almost simultaneous. After producing so many buds, however, the original mother cell almost seems flattened, exhausted, destroyed. The mother cell also has a variable number of nuclei, however, the buds only have a single nucleus.

P. salicorniae is a peculiar species of marine yeast. Scientists have yet to gain a thorough understanding of this yeast, as it is by far the most complex. Starting from a cell that proceeds to be split by septums, much like a pie, it grows arms almost like an octopus. DNA seems to transfer before the buds are produced. Once again, to me, it appears as though it is an almost simultaneous transfer. The arms develop septums. The pie, a dark mass at this point, appears to grow larger and undergoes meristematic conversion, using small round cells produced to build a matrix. This matrix allows cells of *P. salicorniae* to switch between being hyphal cells and yeast cells. Some cells will stay hyphae, while others will stay in the matrix, the giant mass darkened by melanin. To add to the peculiarities of this species, the hyphal and yeast cells seem to have slightly different ideas when it comes to cell size. This would account for the strange appearance of this yeast as it divides. The compartments of the “arms" all vary in size.This species seems to only have one nucleus for each cell or compartment. Until more technology is developed, the mysteries of *P. salicorniae* will remain just that.

Marine yeasts have proven to be extremely hardy when it comes to surviving in a plethora of environments. While these marine yeasts have put their own spin on cell division, it is still through either budding and/or fission that they still divide, like *S. cerevisiae* and *S. pombe*. Marine yeasts may have found solutions to the difficulties *S. cervisiae* and *S. pombe* had such as the problem of coordinating bud formation. Between the species, it is noticeable that in culture, *H. werneckii, K. petricola* and *P. salicorniae* grow very clearly, producing terra cotta pigments on the edges of the growth. *A. pullulans* culture is not nearly as clear, appearing almost fuzzy. The article explained that this was due to melanization under stressed growth conditions. While there are obviously major differences between the marine yeasts mentioned above, they have defining characteristics that show their hardiness and amazing ability to survive. Unlike *S. cerevisiae* and *S. pombe*, they can begin dividing before having completed their cell cycles, allowing for a faster spread and a higher chance of survival. The complexities of cell division and its many forms are still being discovered throughout the many scientific areas. The marine yeasts discovered and examined are undoubtedly just the tip of the iceberg (Mitchinson-Field, 2019).

	H. werneckii	***K. petricola***	***A. pullulans***	***P. Salicorniae***
Cell Cycle Duration (Min.)	730	499	159.5	N/A
Time to First Bud (Min.)	253	110	140	N/A
# of Nuclei	1	1	Mother cell: multiple Buds: 1	1
Growth Pattern	Budding and Fission	Linear Spherical Budding	Simultaneous Budding	Polar, hyphal growth, isotropic growth
Cell Shape	Pill-like	Spheres	Lemon-shaped	Wedge-shaped
Colony Color	Blue; yellow edges	Blue fade to light purple	Yellow	Blue; red edges

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