Marine Yeasts

The oceans cover roughly 71% of the earth's surface and less than 10% of the fungal species have been discovered (Sarkar and Bhaskara, 2016; Allard and Moseley, 2019). When we think of fungi it is common to think of things like the mushrooms we eat, medical infections like foot fungus or maybe mold that can be found under the kitchen sink. Yeast is in this category as well, so things common to us like bread and beer. A large group that isn't talked about in normal conversation is marine yeasts. This group of yeast live in salt and fresh water, sand, marine plants and habitats and even the digestive tracks of birds that eat sea life (Sarkar and Bhaskara, 2016). Marine yeasts are important because they play a big role in the production of different enzymes and bioethanol production (Sarkar and Bhaskara, 2016). Yeast is considered fungi that is in a vegetative state and in this state they with usually grow as single cells, reproducing by budding or fission. Fission is similar to mitosis and budding is more along the lines of simple asexual reproduction. *Candida*, *Cryptococcus*, *Debaryomyces*, and *Rhodotorula* are four common, broad genus types of marine yeasts that will help us better understand marine yeast reproduction and life.

Schizosaccaromyces pombe is a type of marine yeast that uses binary fission to reproduce. Think of a rod shaped cell that elongates at the tip of that rod, it will use fission in the middle of the cell and will split into two daughter cells (Allard and Moseley, 2019). This is a simple reproduction method, and it is comparatively similar to what happens in human cell division. Fission uses miotic cell division followed by cytokinesis (Mr. Doc, 2016). *Cryptococcus* Is an interesting yeast because it uses both budding and sexual reproduction. They are round or oval shaped and can reproduce with normal budding. Sexual reproduction in these yeasts happens when haploid *Cryptococcus* cells fuse together and create hyphae which are thread-like extensions. At the ends of these extensions there is a spore producing structure. This structure produces the spores that produce one diploid nucleus. These spores are a result of mitosis and meiosis (Cryptococcus, 2010).

Saccharomyces cerevisiae is a different marine yeast, but this particular yeast uses budding as its means of reproduction. This one is easy enough to remember, these cells are round and will grow a "bud" and will grow asymmetrically until it is time for cell division to happen (Allard and Moseley, 2019). Unlike fission who creates a daughter cell, budding yeasts will form a new cell on the old cell. If humans were to do this, it would be like a small human growing out of the side of us. *Candida, Debaryomyces*, and *Rhodotorula* all use budding as their reproduction style. *Candida* is a common fungal infection in humans that can be triggered by refined sugars, cars and dairy products that are high in lactose. It can cause fatigue and digestive issues (Candidiasis,2020). *Debaryomyces* is found in soil, sea water and food like cheese. It produces toxins that destroy other yeasts (Al-qaysi, 2017). *Rhodotorula* in humans can cause bloodstream infections (Wirth and Goldani, 2012).

Upon the analysis 4 different types of yeasts then that we originally spoke about, there was a lot of similarities when looking closely at how they divide. Hortaea werneckii is a yeast that can cause a rare superficial skin infection when the fungus comes on the skin due to contact with wood, soil, or decaying vegetation (Mitchison-Field, 2019). It commonly effects the palms

of the hands and the soles of the feet. This black yeast is a plump oval shape and when watching them reproduce under a microscope, there is a noticeable line develop in the middle and the werneckii will start to elongate slightly. At the north and south ends of the yeast, a new yeast starts to grow out of it in a long oval shape, once it gets to the right size it will break off into a beautiful new yeast. Both sides of the cell do this. Then the new yeasts will eventually divide also. These yeasts can reproduce using budding or fission but will generally alternate (Mitchison-Field, 2019).

The second yeast is a rock-inhabiting fungus called Knufia petricola. This type of yeast can enhance the weathering of rocks. The reproduction of this fungus looks pretty fun under the microscope, it starts off as a pretty round little circle then similar to blowing up a balloon, it grows more perfect little bubble circles that have only one nucleus. These just keep on growing and don't break off immediately like the previous yeast Hortaea werneckii. It may be easiest to think of chains when remember their reproduction.

Aureobasidium pullulans is another black yeast that is very similar to Hortaea werneckii. A. pullulans can also be found in soil and dirt. The reproduction of this yeast can be a little chaotic, it first starts off a another plump oval and before it reproduces it visibly expands then shoots out more plump ovals all over and it keeps doing it. It noticeably seemed to reproduce by beginning at the opposite ends of the cell. Each cell that is produced will get a single nucleus even though the mother cell produces up to 6 buds simultaneously (Mitchison-Field, 2019).

The fourth of the yeasts is a funky yeast called Phaeotheca salicorniae that is a black yeast that was first identified in 2016 and there hasn't been too much research done on this fungus since it was discovered. It was documented that this yeast has the most complex reproduction and division patterns out of these 4 yeasts. They start off as seemingly conjoined circles with the same line in the middle as the first yeast, Hortaea werneckii. The yeasts will swell and then grow long extensions from the original conjoined circle. These extensions look similar to tentacles, it will then produce smaller circular cells that are similar to the original yeast cell. These cells will eventually be released and break free by the breakdown of the matrix around them (Mitchison-Field, 2019).

	H. werneckii	K. petricola	A. pullulans	P. salicorniae
Cell cycle duration	710 min	499 min	159.5 min	Na
Time to first bud	265 min	193 min	135 min	Na
Growth pattern	Fission/budding	Multi buds	Multi budding	Hyphal growth
# nuclei	1	1	Mother- multi, bud-1	1
Cell shape	Balloon	Spherical	Balloon	Wedge
Colony color	Olive black	Yellow-green	White, pink, yellow	Green-blue

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