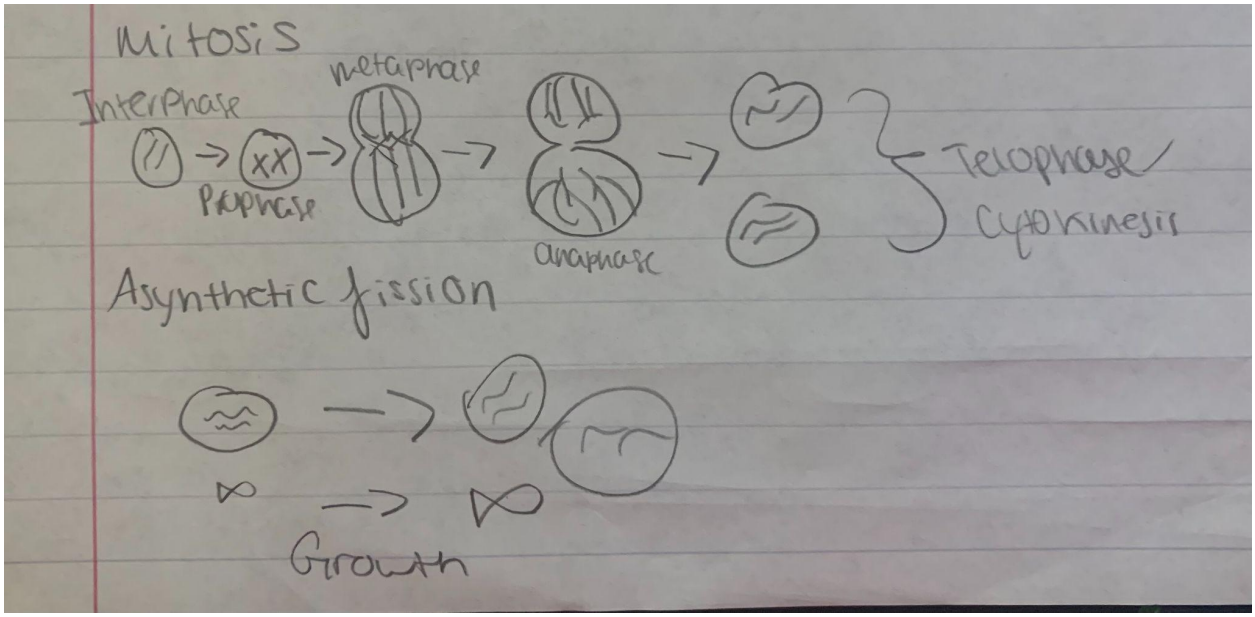
Have Zebrafish Developed a New Kind of Cell Division?

Even though we may not notice it, our bodies exist in a constant state of growth and development. This growth can be traced back to a cellular process known as mitosis. The cells within our bodies use mitosis to replicate themselves. Prior to cell division, DNA is only replicated once per cell cycle. This DNA replication results in two identical diploid daughter cells. Diploid means there are two complete sets of chromosomes in the cell of an organism after the replication of DNA. In mitosis DNA is replicated in the s phase(the s phase is followed by the G_2 checkpoint which verifies DNA). For this to happen the DNA double helix must be separated into two singular DNA strands. A helicase (an enzyme) attaches to the DNA and unzips the DNA strand. These strands will be used as templates for the new DNA strands. These strands have a nucleotide orientation. The leading strand has an orientation of 5' to 3' and the other strand is from 3' to 5' and is called the lagging strands. Everything always moves in the direction of 5' to 3'. Now, to start replication of the two strands a primer, a short nucleic acid sequence that provides a starting point for DNA synthesis, attaches to the 3' ends of the strand. Once that is placed on the strand, another enzyme, DNA polymerase, attaches to this starting point and walks along the strand adding the correct base pairs which are A,T,C, and G while going in the 5' to 3' direction. This is done for the leading and lagging strand. However for the lagging strand since it is going in the other direction it replicated the rest of the strand while the DNA is still being unzipped. With this, the lagging strand only replicated in fragments due to the opposite replication. Ultimately after replication both strands are now two separate strands consisting of one old and one new strand of DNA. Now it goes to mitosis. Mitosis is the process where a cell divides into two daughter cells. In the interphase(where it begins) DNA replicates and prepares for cell division. Once the DNA is replicated we now begin mitosis. The next phase is prophase. Here, the nuclear membrane around the cells begins to dissolve, DNA is more compact and little fibers attach to the middle of the chromosomes. Following is the metaphase. In the metaphase the membrane completely dissolves and the chromosomes align fully in the middle of the cell. Now, separation of the chromatids goes to opposite ends of the cell. These last two steps, telophase and cytokinesis(a separate process of mitosis) form the new nuclear membrane around each new cell and fully divides into the two new daughter cells (cytokinesis). In research there has been a new form of cell division discovered in Zebrafish. During their early development Zebrafish implement a unique form of cell replication called asynthetic fission. Asynthetic fission is unique because in this process the cells can undergo two rounds of cell divisions without DNA replication. (Chan, et al., 2022). Similar to humans, they have 25 chromosomes while we have 23 (Postlethwait, et al., 2000). This Process is advantageous because it can be performed faster than mitosis, however there is a substantially larger margin of error.

While reviewing the article, there are four figures present. The first figure illustrates the process of which they used to identify and track the cells within the Zebrafish. In figure a of figure one, they show the red, green, and blue fluorescent proteins that the researchers used to

dye the cells. Following that in the next figure they show how the die is held in the surface epithelial cells (Chan, et al., 2022). Lastly, in figure one they show how the use of the red, green, blue proteins allows for computers to clearly and accurately analyze the cell and its borders (Chan, et al., 2022). They also zoomed in on the cell and it looked like a fingerprint. In figure two, it looks at a variety of small graphs, each representing individual fish. These graphs look at the length of the fish, the surface area of the fish and the SEC number of the fish. This data is mainly there to visually show how rapidly the fish are growing. In figure three, there is a lot of data to unpack. The data that is shown is to figure out if what is going on normal or something weird is going on that is potentially harming the fish. To understand this, they used a dye that goes into the nucleus so you can fully see the chromosomes and see that they have a nucleus in the cells. Comparing figures b and d we see a decrease in cell signaling. In b you see it in the graph after each division there is less intensity while in d you can actually see the less intense cells after division (Chan, et al,. 2022). This then brings you over to figure n which is referenced in the video. In the video you see four different types of how these cells divide, anaphase bridges, lagging chromosomes, micronuclei, and tripolar segregation. All these figures show a loss of DNA which concludes that this division is abnormal.Figure four focuses on three different fish populations. Panels e and f illustrate how the growth speed of the fish was affected by the population density. The fish in the low density tank grew faster than the fish in the higher density tanks. Additionally, there are close up images of the cells from fish within the three population groups. To conclude, this process does not follow normal mitosis. Normal mitosis follows even numbers. One cell splits into two, two cells split into four and so on and so forth. In Asynthetic fission, one cell can actually split into three which is where these odd numbers can come from. Additionally, one cell could divide into two but, of those two daughter cells only one of those may also divide, leading to an odd number. As well, we could not compare this to meiosis because meiosis also relies on DNA replication (which is not present). Not only that, meiosis is strictly for division of gametes, the reproductive cells. Here, it is only talked about skin surface cells thus not similar to meiosis (Gaur, et al., 2021). The driving reason behind zebrafish evolving to use asynthetic fission during their youth is growth speed. Asynthetic fission allows the zebrafish to grow significantly faster after birth and thus aiding in their survival. As far as the research goes this is not a very common process. However, now that scientists know that it exists they are able to look for asynthetic fission within other species.

Mitosis vs Asynthetic fission:



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