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BIOL 293

Dr. Steel

Word Count: 1253

Cell Death and the Origins of Complex Life: Scientific Literacy Essay

Pyrenoids are the small components that are present in chloroplasts. This organelle is present in apoptosis for a few reasons. A major function of pyrenoids is centres for carbon dioxide fixation, this is done by generating carbon dioxide around the enzyme (Wikipedia contributors, 2021a). Pyrenoids would in turn be affected during apoptosis because the generation of carbon dioxide would be halted. This is a sort of chain of events that leads to this so we know that they do have a role during apoptosis. The nucleus is the second organelle in question and it has a major role during apoptosis. The tearing down of the cell membrane as well as the cell nucleus is the core in destruction/death of a cell. According to Abccam, there is essentially a condensation of the nucleus during apoptosis (Abccam, 2021). Chloroplasts contain pyrenoids so in correlation there is some sort of function in which they are present during apoptosis. However, according to a scientific journal by Aken and Breusegen there is little concrete evidence of how chloroplasts play a role in apoptosis (Breusegen, Aken 2015).

Pandorina morum is a green algae where the cell count can go up to as high as thirty-two but stay as low as eight. In turn we can say that this type of algae is indeed multicellular as well as it does contain a large chloroplast that has at least one pyrenoid. Along with this, the algae are also present in freshwater therefore they would be freshwater or marine algae. (Wikipedia contributors, 2021b). The *Volvox aureus* type of algae is also part of the green algae family, more specifically it is a polyphyletic genus of chlorophyte green algae (Wikipedia contributors,

2021c). It is also a freshwater algae; however volvox aureus is a unicellular organism. There is a singular chloroplast present in this type of algae, while no pyrenoids are present. (Britannica, 2018). Chlorella is a unicellular organism, similar to the volvox aureus algae. This type of algae is found in marine systems most of the time but can be found on land as well. There are single chloroplasts in these algae and within those chloroplasts there are pyrenoids (Wikipedia contributors, 2021d). The Rhodochorton mixed species is a species of algae closely related to the genus of red algae. Parts of this species of algae are located in land areas, like on rocks or some other low lying piece of land. While other parts of this species are located more in intertidal zones, like caves. (Wikipedia contributors, 2021e) It is a multicellular mixed species and there are chloroplasts in these algae but pyrenoids are absent. In conclusion, when looking at freshwater environments, only the pandorina and volvox aureus are completely freshwater algae. Chlorella and rhodochorton are mixed species with some of the species residing in freshwater while other parts reside in other aquatic systems or the land. Pandorina and rhodochorton are multicellular organisms while volvox aqueous and chlorella are unicellular organisms. Finally all of the algae have chloroplasts present within them only rhodochorton algae do not have any pyrenoids present.

For the experiment performed in the research article on cell death the samples of the four algae, *Chlorella sp*, *Volvox aureus*, *Pandorina morum*, and *Rhodochorton* were taken to begin. They were originally taken from a company by the name of Sciento.co.uk and after they were collected, they were automatically sampled to get the basic images and information needed. After this was done, the algae were killed or euthanized in a solution of 300 mM B-mercaptoethanol or BME to abbreviate (Carlisle et al., 2021). This was let set for around a day before the remaining BME was taken out of the test tubes and replaced with freshwater or

seawater respectively. The algae decayed in freshwater if they were green algae and in artificial seawater if they were red algae. This takes into account how they would survive in their true environment. As mentioned before, red algae thrive in a marine environment while green algae thrive in a freshwater environment. Promptly after the different water was placed in the different tubes, they were separated into two groups; oxic and anoxic.

Oxic means that there is a presence of oxygen in the sample while anoxic means that there was lack of oxygen in the sample environment. In the original scientific research article, there is a visual that accurately represents the differences in decay rate for all four algae samples. The samples were taken every other day for a length of six weeks before the final comparisons were made. Ultimately there was a small difference between the two when it came to looking at the rate of decay. When looking at the patterns of decay there was absolutely no difference. There is always room for error in any experiment, in this research article it is explained that there *might* have been an effect on the chemical gradient due to excess water leaking in. The features of the cell that the authors of this research article are showing include the visibility of the nucleus, the holes of the chloroplast and if they are thinner, pyrenoid visibility, collapsed cells, holes in the chloroplasts, and finally collapsed chloroplasts (Carlisle et al., 2021).

The four algae looked at can be related closely to each other when looking at decay rates and patterns. *Volvox aureus* contained an abundance of cells that were held together by a noted extracellular matrix, these cells took their time spacing out which then caused the colonies to misshapen in the longer time frame. The chloroplasts lasted around six weeks after death before they began thinning and breaking into fractions/holes. (Carlisle et al., 2021) The pyrenoids were the least decay resistant, while the chloroplasts were the opposite. *Pandorina morum*'s cells began to decrease in size and separate after the euthanization. The nucleus was still visible and

almost undeformed after the 6 week range. Instead, the pyrenoids were the most resistant to decay while chloroplasts were the opposite; which led to holes and thinned areas. *Chlorella sp* is similar to the two as it has pyrenoids and chloroplasts; however it showed a small amount of evidence to change. The pyrenoids in this cell were the least resistant to decay, while chloroplasts were the opposite; similar to the first two there was thinning and fragmentation of the chloroplasts (Carlisle et al., 2021). *Rhodochorton*, as discussed when establishing the basics, is a red algae that does not contain pyrenoids. The nucleus was able to be observed six weeks after death but the chloroplasts collapsed quickly around three weeks afterwards which led to holes and thinning. It remained in the cell for three weeks afterwards before it fully decayed (Carlisle et al., 2021).

Out of the organelle fossils shown in Figure 4 of the original scientific research article, there is visible imaging of chloroplasts as well as collapsed nuclei and cytoplasms. Yet even though they were observed very quickly after death, chloroplasts are not the most visible in the majority of the fossils shown. A slight image of a cell wall along the various cells in the figure is visible, nonetheless, it is only seemingly visible in the black and white microscopic images rather than the colored images (Carlisle et al., 2021). Due to the previous research on the decay rate and how long it took for the chloroplast to begin having holes in them I was not very surprised to see the features that I saw preserved in the fossils. Many of the nuclei took various amounts of weeks to decay and even then they did not completely disappear from the cells, only began to fragment or drop down slightly.

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