Scientific Literacy Writing: Seeing Around Corners

Through this ePortfolio project we did research on the study done by scientists that observes how cells are able to solve a miniature form of the infamous hedge maze, created by Henry VIII, because they are able to “see” around corners (Tweedy, 2016). The cells that are being observed in this study are cells of D. *discoideum* and pancreatic cancer cells of rats. Like all living things, these cells are attracted to chemicals that help them survive and reproduce. In the experiment, the chemical adenosine monophosphate, also called AMP, is used as the chemical attractant for D. *discoideum* cells which is what the body produces in the process of making ATP (Svedberg et al, 2020). Pancreatic cancer cells are attracted to lysophosphatidic acid, or LPA, which helps fuel cancer progression (Khoi, 2020). Both cells use chemical presences to tell which parts of the maze lead to a dead end and which parts will help them advance to their chemoattractant. This process is called chemotaxis. Chemotaxis is when cells use chemical concentrations to tell where they are in their environment.

In the cell maze experiment, both self-generated gradients and imposed or static gradients were initially observed. In Fig. 1 from the experiment (Tweedy et al, 2020, pp. 369), the difference in imposed and self- generated gradients is exercised. It is easy to see that the self-generated gradient made for the most progress toward the attractant in comparison to the imposed gradient. Self-generated gradients are most effective because as the attractant concentration changes, the cell respond allowing them to move more efficiently toward their attractant. Unlike the self-generated gradient observed, the imposed gradients peak concentrations at dissociation constant for receptors, making the cells respond in a random pattern (Tweedy and Insall, 2020, pp. 133). It was concluded in the experiment that with a self-generated chemoattractant gradient that the cells were able move with great efficiency.

The results showed that the D. *discoideum* cells were able to solve every microfluidic maze faster than the cancer cells, but this did not necessarily mean the D. *discoideum* cells had a greater fidelity. It was hypothesized that the slower cells moved, the more accurate their decision making would be (Tweedy et al, 2020, pp. 369). However, when comparing the two different cell types they had similar success rates. This contradicted the prediction since the D. *discoideum* cells took two hours to finish the maze and the cancer cells took two days. D. *discoideum* cells that move quicker are attracted to cAMP which diffuses much faster than the chemoattractant LPA that the pancreatic cancer cells were attracted to. Even though the different cells observed moved throughout the same maze at different rates, their fidelity was similar, showing that speed is not a great factor in fidelity, but the relation of cell speed to the chemoattractant dissipation rate.

When comparing the computer simulations to the results of the mazes, the computer simulations were rather accurate. The more distant and complex dead endsmaze in Fig. 3 from (Tweedy et al, 2020, pg. 369), had the computer simulation predicting a graph trend that was most similar to the D. *discoideum* results. It predicted the simple maze would result in the greatest fidelity, followed by the short maze then the long maze. The D. *discoideum* function line looks similar to the simulation unlike the pancreatic cancer cell graph that looks stair like. Something that could account for this would be the time the cells took to solve the maze. The pancreatic cancer cells took 50 hours to solve the maze unlike the D. *discoideum* cells that only took 1 hour. The average number of cells with a positive bias in the simulation was similar for the D. *discoideum* cells but the pancreatic cancer cells had a much lower average number of cells.

The computer simulation of results in testing the approach length and the mirage reservoirs had a correct prediction. While the simulation had greater differences in the correct and incorrect bias, the trend showed that the longer the approach length, the less mistakes were made by the cells. This was credited to the proximity of the mirage reservoir to the large chemoattractant reservoir. Since the approach length increased the attractant reservoir and mirage reservoir were closer together, so the stronger concentration from the attractant reservoir overpowered the mirage reservoir; making cell decisions for a positive bias more likely**.** It was observed in Fig. 5 from (Tweedy et al, 2020, pp. 369) that some cells who chose the mirage reservoir would then receive a stronger signal from the chemoattractant and would correct their pathway decision. Looking at the graphical data for this the simulation, it shows a greater difference in the positive and negative bias than the actual experiment, but the shape of the graph lines looks similar.

Throughout the experiment different mazes were tested in order to get a full understanding of how these cells respond to the gradient and use chemotaxis. The accuracy for cells in the simple mazes was very high. The trend shows cells committing to a dead end is directly correlated with the length of the dead end. In the shorter dead ends, cells were able to tell there was no attractant in the reservoir, so they were able to make an accurate decision.  This was because the chemotactic cells are able to differentiate 1% gradient differences in short distances, typically 0.5 to 1mm in length.

As for the intermediate mazes, most cells made an error at first decision because the attractant had no reached the beginning of the maze, but after that they were more accurate.The data in Fig. 3 from (Tweedy et al, 2020, pp. 369) showed that most cells were 50/50 at the first decision point, and after they were very accurate in finding the source of chemoattractant. After the first decision there would become more and more concentrated making the pathways to the attractant more obvious. This is why the second and third decision points were more accurate as seen on Fig 3. (Tweedy et al, 2020, pp. 369).

The most difficult mazes were the labyrinth mazes. Complexity of the labyrinth maze affected the fidelity of the cells ability to locate the chemoattractant. In the simulation video, movie S7, (Tweedy et al, 2020, pp. 369) it is seen in the hard labyrinth that the diffusion of the chemoattractant dissipates much faster through the maze than attractant in the easy maze. The hard maze and easy maze had the same amount of dead space, but the hard labyrinth was made with longer dead ends; the pattern of long dead ends causing less fidelity was the same as the simple mazes in the beginning of the experiment.

The scientist preforming this study were able to conclude that self-generated gradients allow cells to solve many different microfluidic mazes with great fidelity. By creating different mazes, the scientists were able to observe different factors that affect the cells ability to find the chemoattractant. Different variables discussed such as maze lengths, complexity, number of pathway decisions made, and varying mirages changed the way cells performed using chemotaxis. By better understanding the migratory behaviors of cells we will get more insight into the wonders of many physiological behaviors we yet to understand.

References

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