Case Study 7 : Aging Dependence Environmental Entropy : Dominic Giannangeli

Background:

Genetic expression of proteins, signaling pathways, and environmental stimulus have all be subject to experimentation due to their contribution to aging. For example, activation of the mTor pathway, which regulates metabolism and growth, is inversely proportional to aging. Likewise, the depletion of Daf-2 expression, which is a growth factor that stimulates metabolism in C. elegan worms, increases lifespan. In addition, dietary restriction increases life span in many different organisms [2]. These three examples have one thing in common, they decrease the metabolic processes within organisms which increases lifespan. The consumption and processing of energy increases the rate at which biological processes are activated. This would in turn increase the interaction of the organism with its environment. This process is a positive feedback loop. As energy is input/consumed, it is processed (transduced into a useful form through biological metabolic pathways), which is then used as fuel to increase the organism's interaction with its environment. The Second Law of Thermodynamics states that no process is 100% efficient. In other words, waste heat will be produced as energy is transformed within a process [3]. This would mean as biological metabolic processes increase in frequency, there is more waste energy produced within the system that interacts with the organism. This statement aligns with information collected from aging experimentation. This could mean entropy in environmental stimulus will also increase the rate of aging.

Purpose:

The purpose of this plan is to evaluate the effect of entropy in the environment (lack of predictability and useful informational) on aging. To more specifically, evaluate the effects of informational noise on lifespan.

Research Plan:

Information entropy within the environment can be thought of as a stimulus that has no meaning. It is noise. The informational noise will effectively decrease the efficiency of an organism to find, consume, and process energy needed for survival. (Ex. Trying to have a conversation in a noisy environment. You may have to repeat yourself, using more energy to generate each repetitive sequences of spoken word. Therefore, wasting energy with respect to an efficient conversation).

To model this, C.elegans will be used. C.elegans are a simple organism that seem to spend most of their life looking for food and a mate. They sense their environment (collect information) through chemical signals and move in the direction of concentration gradients. They move toward a greater concentration of a chemical associated with food and/or a mate. To help induce entropy or noise into the signals collected from their environment, ChR2 optogenetic trans-membrane protein will be implemented into their genome. The ChR2 will be expressed in AIY interneurons of the C.elegans. Stimulation of AIY interneurons will cause the C.elegans to move in the direction of their head position at the time of simulation. Two groups of C.elegans will be put into two different enclosed chambers. Both groups will have ChR2 expressed in the AIY neurons. One group will be a control and the other group will be subject to pulsing 480 nm light (by a laser system) throughout their lifespan. When these light pulses interact with ChR2 expressed in the worm's neurons, an action potential will be generated causing the worm to move in a direction that is not toward a food or a mate. This will effectively introduce noise into the informational input that codes for useful energy. The worm will then need to reorient itself to follow the chemotaxis path that will lead them food or a mate. This decrease in efficiency will cause the worm to work harder to collect nourishment needed for life, due to entropy within its informational input. Both groups will be provided the same amount of food and the same environmental factors such as temperature. The average life span between worms in the two groups will be analyzed and compared. If the worms in the noisy environment have a decreased lifespan, informational entropy could influence longevity of life. [1].

References

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[2] DiLoreto, Race, and Coleen T Murphy. “The cell biology of aging.” *Molecular biology of the cell* vol. 26,25 (2015): 4524-31. doi:10.1091/mbc.E14-06-1084

[3] Admin. “Second Law of Thermodynamics - Statements, Examples, Equation.” *BYJUS*, BYJU'S, 17 Sept. 2021, https://byjus.com/jee/second-law-of-thermodynamics/