Project No.	Project Title	
2021 -01-142	Understanding Resource Optimization in Man-made and Natural Systems	
Academic Advisor	**Co-Advisor**	
Dr. Rami Pugatch	Dr. Anjan Roy	
Team Members		
Adiel Klein		
adielkl@post.bgu.ac.il		

Abstract

Bacterial cell self-reproduces by consuming raw materials and converting them into essential building blocks and energy. The replication process is elaborate and comprises many different sub-processes such as DNA replication, membrane synthesis, protein synthesis and replication of the protein synthesis machinery.

In order to operate, the bacterial cell is required to allocate its resources among these different processes. Although many details regarding resource allocation are known, the question is still open and contains many experimental observations that await explanation.

For example, the optimal adaptation of a certain bacteria to a change in their environment suggests that an optimally tuned feedback controller is in action. However, a naive application of feedback control requires a specific tuning of its defining parameters, and it is not clear how the cell auto-tunes these parameters in case of an environmental change. Furthermore, the criterion for optimization, selected by evolution, is still unknown and being debated. Does the cell try to optimize its growth? Efficiency? Long-term survival?

This work we study some simplified models, which will allow us to focus on different aspects of the allocation process and to analyze them, thus, gaining insight on more nuanced and complex models which will reflect actual biology more accurately. Like any model, we omit parts which we believe are of lesser relevance to the questions we ask, and compare the predictions we get from this simplified picture against the complex reality as reflected in experiments.

Our initial assumption was that a bacterial cell tries to optimize its growth, and in accordance, we created a model which analyzes the behavior of bacterial cells in a state of abundance of external substrates and in a state of limitation of resources. We found that the bacterial cell allocates resources to the most efficient path (in terms of time and cost of production). Also, we found that in a state of limited resources, the bacterial cell can switch energy production to more efficient growth paths. In addition, we conclude that the maximization of the growth rate and the maximization of the EsEROI have the same rules of preference.

Keywords: Bacteria Cell Growth, Energy Production, Operations Research, Energy Efficiency, Growth *Optimization*