Optimizing Escherichia coli Energy Usage for Chemotaxis and Reproduction Through Experimental Evolution

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In bacteria, cellular energy is largely consumed by two essential functions: reproduction and chemotaxis, the behavior where single-celled organisms swim up a gradient of nutrients. When both functions are selected simultaneously, the finite energy output of the cell causes a tradeoff between chemotaxis and reproduction. In this research, I implemented a stringent selective scheme forcing E.coli to fully maximize energy usage by selecting both functions continuously and simultaneously. Bacteria were reproduced in aqueous medium with limited diffusion; the growing population depleted ambient nutrients, creating a gradient for the cells migrate towards. Hence, the migration speed is a function of both reproduction and chemotaxis. For reasons still being researched, identical bacteria populations evolved different strategies in response to the selective pressures in the aqueous environment. In order to eliminate the temporal variation of the aqueous selective scheme that allowed for the divergence in evolved strategies, I designed a semi-solid "treadmill" that constantly selects only the bacteria that migrate the fastest most effectively. Cells are sampled from the migrating population and their migration speed, rate of reproduction, and average cellular swimming speed are analyzed in a standardized test. This data is used to determine how E.coli (re)allocates energy between chemotaxis and reproduction in order to achieve the fastest migration speed and most effective energy usage. These results provide novel insights on how cells adapt to complex environments in the face of fundamental physicochemical constraints of life.