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Modeling sodium pump degradation and removal: Sorting out your dirty laundry

Sareh Rajaee and Mark Milanick

We live in a society where time management and energy efficiency are important productivity skills. A prime example of this is sorting through ones clothes: is it more time and energy-effective to search through a pile of clothes to pick out the dirty articles than to just put the whole pile in the wash? One may apply this same question, on a much smaller scale, to the human cell: what's the best strategy for removing damaged sodium pumps? Is it more time and energy-effective to search through the Na pumps to find the damaged ones than to just to remove all the pumps periodically? Na pumps are synthesized in the Endoplasmic Reticulum (ER), moved to the Golgi, then to the Plasma Membrane (PM), then to the early and late endosomal compartments, and finally degraded in the lysosome. Four cases of Na pump trafficking were studied: the control case, where each step is random and reversible, except for translation to the golgi and from the late endosome to the lysosome; the first case, which was an extension of the control with one irreversible step from the early endosome to the late endosome; the second case, which was an extension of the control with one irreversible step from the plasma membrane to the early endosome; and a final case, which was a combination of the control case and the first two cases. These cases were modeled using Microsoft Excel and Visual Basic Editor. Seven numerical values (0-6) signifying various stages of protein trafficking were randomly assigned to each protein at each time interval. In order to evaluate all four cases, five trials were completed. During each trial, one hundred proteins were studied for each of the four cases, and a bar graph was generated each time to show the distribution of times for the proteins to reach degradation (the final stage, 0). After having found that identifying damaged Na pumps significantly decreased the amount of time on average that it takes for a pump to reach degradation, we are developing models to additionally study the energy cost-affectivity of this process. So it is more time-effective to sort through your clothes for the dirty laundry, but does it ultimately cost more energy?