Queuing theory helps physicist understand protein recycling

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We've all waited in line and most of us have gotten stuck in a check-out line longer than we would like. For Will Mather, assistant professor of physics and an instructor with the College of Science's Integrated Science Curriculum, studying lines, or queues, has been crucial in trying to understand how cells deal with bottlenecks that limit the recycling of proteins.

The work, submitted during Mather's first semester as an assistant professor, has received attention from the National Science Foundation in the form of a $960,000 grant.

Leveraging the history of queuing theory, and working at the intersection of statistics, physics, engineering, biology, and computer science, Mather tries to extend an understanding of waiting in line to how cells operate, especially as it relates to what the consequences could be of protein traffic jams inside cells.

"If you consider the analogy of a subway, it's a fairly apt one," Mather said. "A subway can deal with a certain number of customers with its limited number of outlets. If the flow is correct, the system works fine. If people arrive in bunches, it can jam the system. The same is true in cells."

In the subway analogy, enzymes act as gatekeepers while proteins are the customers. The proteins are trying to be recycled, so they can be made into other proteins, but the enzymes can only handle so much traffic and

proteins are either not recycled or they need to find alternative pathways.

"By better understanding these pathways we find associations with development, inflammation, cancer – they are all potential areas of impact," Mather said. "In principle, every cell has limited resources available to recycle proteins. The paths associated with what we consider positive development for those proteins might cross talk with paths associated with information transmission, or less desirable outcomes such as cancer.

"What we're doing now is using a simple, common bacterium, *E. coli*, and using fluorescent proteins to see how circuits behave in individual cells in an effort to understand the effect of these pathways," Mather said.

By understanding these bottlenecks, Mather seeks to discover the mechanism behind how cells naturally alleviate bottlenecks by directing their proteins to different 'servers' to be recycled. He said his research will then produce intuitive and powerful quantitative models for these bottlenecks, as well as create new molecular tools for synthetic biology and biotechnology in general, which will allow for the construction of large, scalable bio-circuits in bacteria.

This, he says he believes, will push the frontiers of both traditional and synthetic biology.

Mather received his bachelor's degree and Ph.D. from Georgia Tech. He arrived at Virginia Tech in 2012.

Provided by Virginia Tech