

# Biology's need for speed tolerates a few mistakes

May 2 2017

---



Anatoly Kolomeisky, left, and Oleg Igoshin. Credit: Jeff Fitlow/Rice University

Biology must be in a hurry. In balancing speed and accuracy to duplicate DNA, produce proteins and carry out other processes, evolution has apparently determined that speed is of higher priority, according to Rice

University researchers.

Rice scientists are challenging assumptions that perfectly accurate transcription and translation are critical to the success of biological systems. It turns out a few mistakes here and there aren't critical as long as the great majority of the biopolymers produced are correct.

A new paper shows how nature has optimized two processes, DNA replication and protein translation, that are fundamental to life. By simultaneously analyzing the balance between speed and accuracy, the Rice team determined that naturally selected reaction rates optimize for speed "as long as the error level is tolerable."

The paper in the *Proceedings of the National Academy of Sciences* is by Rice postdoctoral fellow Kinshuk Banerjee and his advisers, Oleg Igoshin, an associate professor of bioengineering and biosciences, and Anatoly Kolomeisky, a professor of chemistry and chemical and biomolecular engineering.

Their technique allowed them to see that while [error correction](#) through kinetic proofreading leans toward speed, the cost of going as fast as possible could sometimes be too big.

Kinetic proofreading is the biochemical process that allows enzymes, such as those responsible for protein and DNA production, to achieve better accuracy between chemically similar substrates. Sequences are compared to templates at multiple steps and are either approved or discarded, but each step requires time and energy resources and as a result various tradeoffs occur.

"Additional checking processes slow down the [system](#) and consume extra energy," Banerjee said. "Think of an airport security system that checks passengers. Higher security (accuracy) means a need for more

personnel (energy), with longer waiting times for passengers (less speed)."

The researchers found the prevalent theories unsatisfying when they became interested in learning how nature corrects its errors.

"I've never been happy with the way people look at biological error correction mechanisms because their approaches were oversimplified," said Kolomeisky, who studies the mechanisms of biological systems. "I wanted a more comprehensive framework, so we could look at both the right and wrong pathways for replication and translation, as well as for other processes.

"We developed a powerful quantitative method with which we can simultaneously calculate error, speed and energy costs, where previous methods only focused on errors," he said.

"We saw what was missing," added Igoshin, whose lab at Rice's BioScience Research Collaborative studies computational systems biology. "By simultaneously analyzing several parameters, we can see the interplay between energy, error and speed and determine where optimization occurs."

While speed is still a priority, [biological systems](#) sacrifice a bit by fine-tuning error correction. Graphs produced by the Rice calculations show that when protein replication is limited by just a percentage point or two below maximum speed, the accuracy remains high and [energy](#) savings are significant.

"It is perhaps not that surprising that accuracy is not the only concern for the system," Banerjee said. "What is fascinating is how the systems optimize their performance by fine-tuning these apparently opposite objectives while taking care of the energetic cost."

The concept of [speed](#) versus [accuracy](#) has already been explored in a very different system at Rice through work by computer scientist Krishna Palem, who created microprocessors that increase their efficiency by allowing slight imperfections in their calculations.

"That makes just as much sense for biology as it does for engineering," Igoshin said. "Once you're accurate enough, you stop optimizing."

**More information:** Elucidating interplay of speed and accuracy in biological error correction, *PNAS*, [DOI: 10.1073/pnas.1614838114](https://doi.org/10.1073/pnas.1614838114) , [www.pnas.org/content/early/2017/05/01/1614838114.abstract](http://www.pnas.org/content/early/2017/05/01/1614838114.abstract)

Kinshuk Banerjee et al. Accuracy of Substrate Selection by Enzymes Is Controlled by Kinetic Discrimination, *The Journal of Physical Chemistry Letters* (2017). [DOI: 10.1021/acs.jpcllett.7b00441](https://doi.org/10.1021/acs.jpcllett.7b00441)

Provided by Rice University

Citation: Biology's need for speed tolerates a few mistakes (2017, May 2) retrieved 25 April 2024 from <https://phys.org/news/2017-05-biology-tolerates.html>

This document is subject to copyright. Apart from any fair dealing for the purpose of private study or research, no part may be reproduced without the written permission. The content is provided for information purposes only.