# Your students test their own **hypotheses** about mutation and evolution with **AVIDA***

## *Is mutation a creative or destructive force in evolution?*

*Students can test common misconceptions with AVIDA*

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https://qubeshub.org/qubesresources/publications/1224/1

Most biologists would agree it is both, but how does one present the subtle distinctions to undergraduates in an engaging, exploratory, and data-generating laboratory exercise? AVIDA* offers a perfect platform on which students generate and test hypotheses, modeling virtual organisms as mutations occur at random locations in their genome. Each is like how a new biochemical pathway due to mutations in enzyme-coding genes allows a bacterial population to metabolize novel chemical substrates (either for energy or as defense against antibiotics.

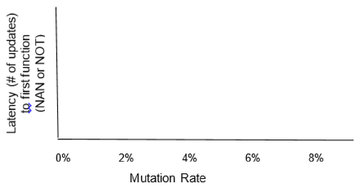
**Exercise 2 - Mutation is a creative and destructive force in evolution**

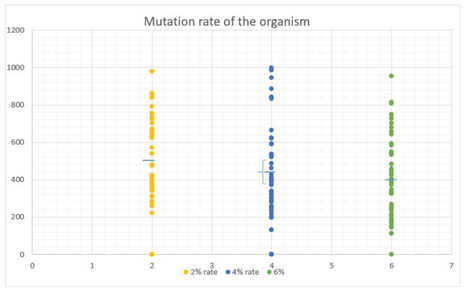
Student Learning Goals

- Students will describe the role of random mutation as a force that may by chance create useful phenotypic changes (AVIDA's metabolic functions) but may also disrupt useful functions--as such it is neutral with regard to consequences and not goal-oriented
- Students will appreciate that these random processes require many generations to result in notable phenotypic changes (for better or worse)
- Students will create a graph of the results of multiple simulations with proper axes and error bars showing the relationship between mutation rate and number of generations for the population to attain new functions

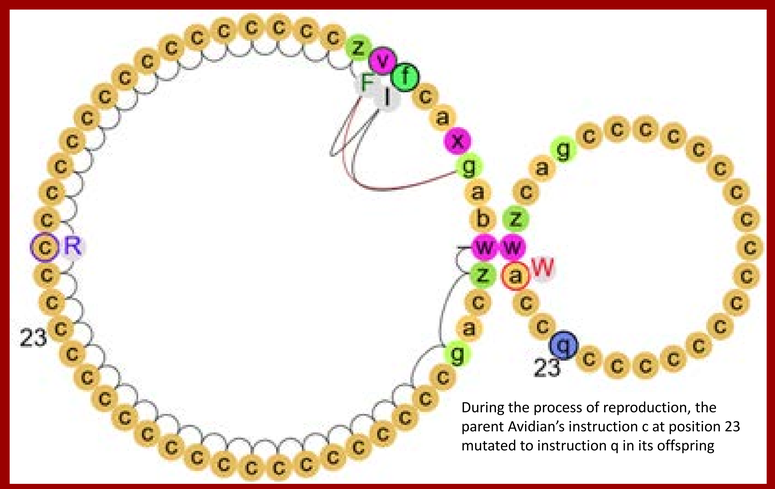
Driving Questions

- In Natural Selection how is mutation sort of like a "loose cannon" in a chaotic battlefield?
- What do you expect a graph of mutation rate vs. time for a population to attain any evolved functions would look like? Draw it in below:




Example of student data on the LFF – latency to evolve NAN in a series of replications. 26 Students pooled data from their runs on a Google sheet, then calculated means, standard deviation, and standard error (SE) The bracket for 1.9 SE is included for the 4% rate. The 2% mean (524) is slightly higher than the 4% bracket so is significantly different at the 95% confidence level (4%: 443± 63.5). A second section obtained the same qualitative result from their simulations using the NOT function.




During the process of reproduction, the parent Avidian's instruction c at position 23 mutated to instruction q in its offspring

Take a picture to download the full paper

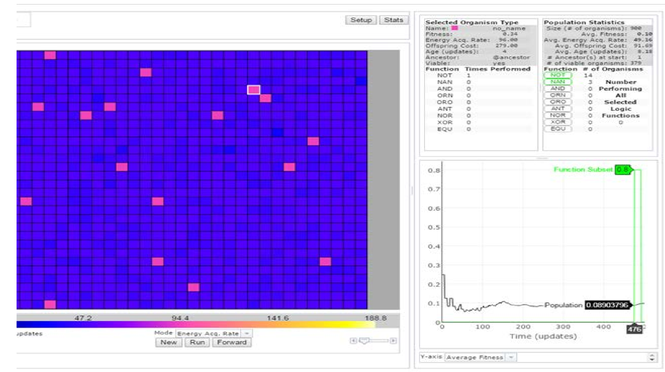


**Figure 1** shows the aftermath of an instance of the acquisition of both NOT and NAN in an Avidian. The simulation was paused at update 500, shortly after the individual died. But it had so altered the relative energy acquisition rate that squares that had been magenta are now blue, and those that had been yellow (having a single function) are now magenta. You can see on the graph exactly when this individual appeared and then perished by moving the cursor on the rectangular green trace..

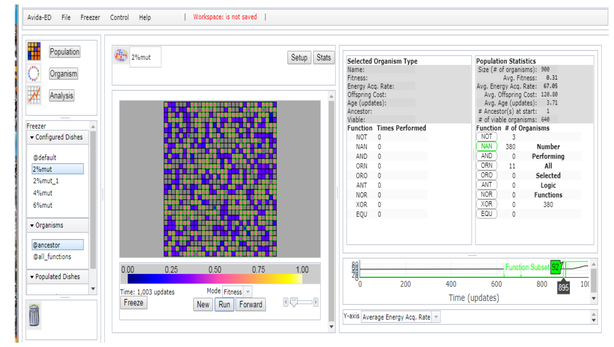


**Figure 2**. In this run (at 2% mutation rate) only the nonose resource was available and the NAN function was checked (green) in the Population Statistics Window. On the timeline we can see when the function first appeared (around update 635) and reappeared several times, the latest being at update 895. Although not rewarded by a resource, note that NOT was performed by 3 members of the final population, while ORN, a more difficult function, was performed by 11!

*AVIDA is a program designed by researchers at Michigan State University to evolve virtual organisms with genomes that mutate at random and can fortuitously develop Boolean functions that can help Avidians replicate, just as haploid organisms do. AVIDA-ED provides a free, and easy to learn, experimental platform for the study of evolution in which students can design experiments to test hypotheses that relate to actual organisms and real-world concerns such as antibiotic resistance. Go to https://avida-ed.msu.edu/app/AvidaED.html

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