Comparing the ability of organisms with varying selective advantages to proliferate in different environments

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Introduction

Research Question:
Will mutations for two equally attainable resources proliferate at the same rate?

Why should you care?
- Give insight into how mutations respond to the environment and can influence the diversity of a population

Hypothesis and Predictions:
- H_A: If two different resources are easily attainable by the same organism, then the organism will proliferate just as well as the other in environments containing their respective resource.
- P_A: If notose and nanose are both easily-attainable by Avidians, then Avidians capable of using these resources will proliferate equally as well in environments containing their respective resource.

Background:
- Environmental factors can influence specific mutational events[1]
- Mutations do not depend on presence of environmental resources[2]
- Organisms in varying environments may adapt based on resource abundance[3]

Methods

Parameters of initial dish:
- 60x60 cells, 2% mutation rate, all resources turned off

Generate 6 mutant Avidians:
- Initial dish parameters with Ancestral organism
- Run test until one notose-performing Avidian appears and place in freezer
- Repeat 2 times
- Repeat process to obtain 3 nanose-performing Avidians
- Make sure all individuals can reproduce (Figure 1)

Test Avidians in no resource environment:
- Put individual mutants in environment with initial parameters
- Replicate for 250, 500, and 1000 generations (updates)
- Record number of organisms able to perform notose (or nanose) and total population size at each chosen update

Test Avidians in benefitted environment:
- Put individual mutants in their respective resource environments with 60x60 dish size and 2% mutation rate
- Record number of resource-performing individuals and total population size at 250, 500, and 1000 generations

Data Analysis:
- Calculate average and standard deviation
- ANOVA test followed by Tukey test

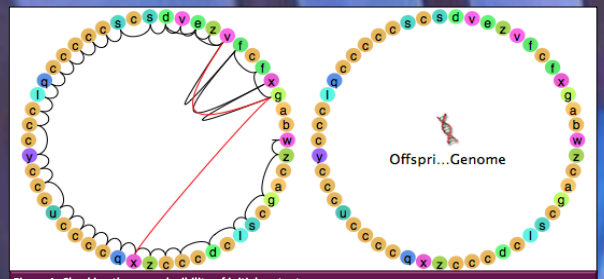


Figure 1. Checking the reproducibility of initial mutants.
This picture shows the parent and offspring genome of our Not-1 mutant. The fact that the parent was completely replicated indicates that it is able to reproduce and can be used in the later tests. Each letter is indicative of a single gene.

Abstract

It is accepted that mutations occur spontaneously and that organisms with a selective advantage prosper more than those who lack it. However, it is difficult to isolate specific mutations to observe their effects individually. This is what the Avida-ED program allows us to do. The aim of our experiment is to isolate two different mutations that give Avidians an advantage for two different, easily-attainable resources and see if there is a difference in the rate at which the mutations proliferate in environments with and without a reward. We hypothesize that both mutations will proliferate at the same rate in environments where they are not rewarded and those where they are, since both resources are easily attainable. We generated 3 notose and nanose-performing Avidians each, then tested them individually in an unrewarded and a rewarded environment. We recorded the number of resource-performing Avidians and the total population size after 250, 500, and 1000 generations in each run. With this data, we calculated the averages and standard deviations, then ran an ANOVA and Tukey test to determine if it is significant. The ANOVA test resulted in a p-value less than .001 and an F-statistic of 136.34 when comparing all four categories. The Tukey test specified that there was only significance between the use of a reward and default environment; but no significance between the Notose and Nanose performers.

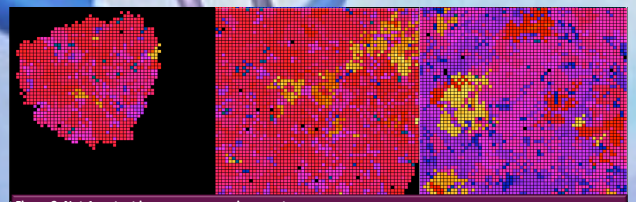


Figure 2. Not-1 mutant in no resource environment.
These images show the proliferation of our Not-1 mutant at 250 generations (left), 500 generations (middle) and 1000 generations (right). The color of each Avidian represents its fitness in the population. Light colors are better fitness with yellow being the highest.

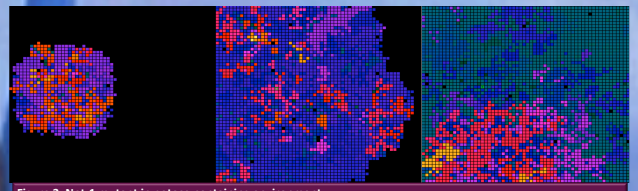


Figure 3. Not-1 mutant in notose-containing environment.
This series of images shows the proliferation of our Not-1 mutant in an environment containing notose at 250 generations (left), 500 generations (middle) and 1000 generations (right). The color of each Avidian represents its fitness in the population. Yellow is the highest fitness indicator.

Results

No Reward
- As updates increased, percentage of Avidians performing notose decreased (250 updates: 0.136, 500 updates: 0.042, 1000 updates: 0.005)
- Percentage performing nanose showed the same trend (250 updates: 0.138, 500 updates: 0.041, 1000 updates: 0.004)

Reward
- No distinct trend, Avidians performed notose and nanose at very similar percentages
- Notose- 250 updates: 0.437, 500 updates: 0.395, 1000 updates: 0.332
- Nanose- 250 updates: 0. 344, 500 updates: 0.405, 1000 updates: 0.454

Fstat -136.34, p value - <.0001, with resource vs. without resource.
Tukey - notose vs nanose non significant

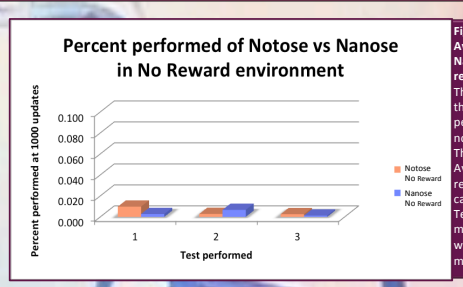
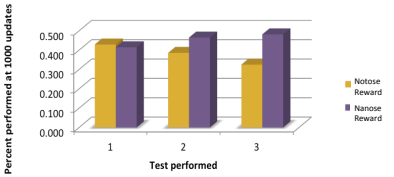


Figure 4. Average ratios of Avidians performing Nanose vs Notose in a no reward environment.
The graph to the left shows the average percent performed of nanose and notose at 1000 updates. The ratios of performing Avidians from three no-reward tests were calculated and averaged. Test 1 and 3 resulted in more notose performed while test 2 resulted in more nanose performed.

Figure 5. Average ratios of Avidians performing Nanose vs Notose in a reward environment.
The graph to the right shows the average percent performed, at 1000 updates, of nanose and notose. Three tests were performed identical to the tests in figure 4 but with rewards given. Tests 1, 2, and 3 all showed no distinct difference between performance of notose vs nanose. The columns all show ratios of 0.31 – 0.45.



Discussion and Conclusion

- In an environment with a reward present, Avidians performed nanose and notose at a higher frequency then when no reward was present
- Nanose and notose increase in frequency of populations at similar rates
  - Rearrangement of data may be necessary to show possible significant difference
  - Difference was detected when in the same environment
- Supports H_A: Avidians performed equally regardless of resource (nanose vs notose) -more mutations present when in a resource abundant environment
  - Averaged between 0.394-.0.454 for both
- In an environment with no reward present, the percentage of mutating Avidians decreased with more generations
  - Averaged 0.0045 percent performed compared to 0.392 in reward environment with 1000 updates
- Validates P_A: Avidians easily attained both resources (nanose and notose) and performed them in similar percentages
- Implications: Mutations seen in Avidians contribute to knowledge of more complex organisms-further test for mutational comparisons between different bacteria in similar environments
  - Help improve our understanding of how environmental resources affect rate of mutation
  - By identifying environments that trigger proliferation of certain mutations for diseases such as tuberculosis, scientists can better isolate the mutations and develop ways to hinder their growth
- Further testing: do mutations follow the same pattern in other resources?
  - Avidians placed in resources other than nanose and notose

References

1. Massey, R. C., Rainey, P. B., Sheehan, B. J., Keane, O. M., and Dorman, C. J. 1999. Environmentally constrained mutation and adaptive evolution in Salmonella. *Current Biology* 24: 1477-1480.
2. Luria, S. E., and Delbrück, M. 1943. Mutations of bacteria from virus sensitivity to virus resistance. *Genetics* 28: 491–511.
3. Burger, R. 1999. Evolution of genetic variability and the advantage of sex and recombination in changing environments. *Genetics* 153: 1055-1069.