Artificial Selection: Evolution in Practice

Researchers can select for resistant bacteria in order to study their genomes.

Background

Researchers use models to test hypotheses when experiments with the actual system of interest would take too long to perform, be too difficult to manage, or too expensive to conduct. For this project, you will use digital organisms to model evolving bacterial populations. In real life, bacterial populations can double as quickly as every 30 minutes. However, this is still too slow to be of practical use in answering certain questions. To overcome this problem we can use digital organisms in Avida-ED, where doubling times can be as little as one second.

Imagine that the "oro" function in Avida-ED codes for an enzyme that can degrade a substance known as trichloroethylene, or TCE. Your job in this exercise is to evolve organisms that perform "oro" (see the Design Challenge Scenario below). Beginning with the default organism (@ancestor), change any of the environmental settings and use many different environments over the course of your experiment. Your goal is to determine the best procedure for evolving a population that most effectively metabolizes the "orose" resource in an environment with only "orose."

Assignment Tasks

Design Challenge Scenario
Your school administrators want to buy a plot of land adjacent to the school to accommodate new athletic facilities. The property includes a large warehouse that has been used for various industrial purposes over the last 50 years. During the site inspection, it was discovered that the soil and water around the warehouse are contaminated by trichloroethylene (TCE), a hazardous chemical used as a spot remover in dry cleaning and as a degreaser for metal parts.

The school board has asked your class to team up with an environmental consulting company to help clean up the TCE so that your school can move ahead with purchasing and using the land. The environmental consulting company has informed you that current methods for TCE abatement are expensive and require the contaminated soil to

be removed and disposed of in hazardous waste dumps. The company is interested in spiking the soil with bacteria that can biodegrade (break down) the TCE. Your goal is to develop a protocol for evolving a bacterial strain that can biodegrade TCE (i.e., perform the "oro" function). You must convince the company (using data to support your claims) that your protocol will lead to an efficient means of evolving TCE degrading bacteria. The company can then use your recommendations to mass produce the bacteria and clean the soil on-site instead of dumping it into a hazardous waste landfill.

Before going any further, discuss the following questions:

1. What do you know, or think you know, about this problem?

2. What things do you not know, or need to know, about this problem?

Experimental Design
Design the experiment to answer the following question: What conditions will lead to the evolution of the most efficient TCE degrading bacteria? Use the questions below to guide you through the experimental design process.

1. Write a hypothesis to answer the question, and include a justification (why do you think these conditions are ideal?).

2. What data will you need to collect in order to test your hypothesis? How many data points (number of replications, variables, etc.) do you need to be able to confidently support or reject your hypothesis?

3. Describe your experimental design. Make this a concise description of your methods (including settings, replications, data collection, etc.) that is clear enough for another group to replicate.

4. How will you organize your data as you collect it? Make a data table to fill in during the investigation.

5. How will you present the data in order to make patterns in your data clear?

Conclusion
Write a paragraph describing how your results support or refute your hypothesis.

Proposal
Propose a protocol for evolving bacteria to degrade TCE (perform "oro") based on the results of your investigation. Prepare a brief presentation to the class explaining your proposal.

Discussion
As a class, evaluate the proposals and determine which protocol most effectively evolves efficient TCE degrading bacteria. Are there any unanswered questions? Your class may find that you have a protocol that you feel confident submitting to the environmental consulting company or you may decide that you need to run more experiments before doing so. It is important that you present data in support of your protocol in order to convince them that your protocol is likely to lead to a feasible plan for evolving TCE degrading bacteria.