

Student Name: \_\_\_\_\_

**Understanding Mutations and Their Role in the Evolution of a Varied Population Using Avida-Ed  
By Kimberly J. Bolyard and Moshe Khurgel**

Learning Outcomes

- describe how mutations affect the phenotypes and fitness values of organisms
- describe how characteristics of a population change over time and how these are related to characteristics of individuals in the population
- describe how the environment affects the fitness of different phenotypes

General Instructions

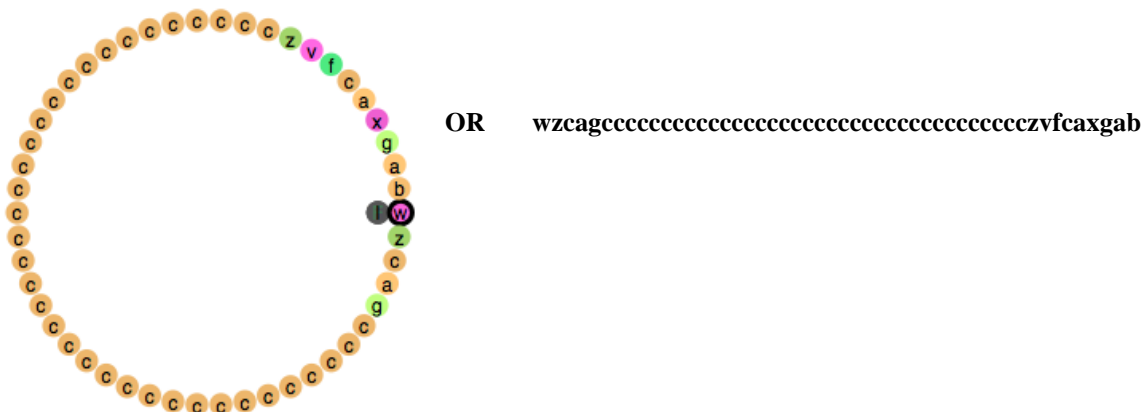
1. Read through the entire packet of instructions before starting.
2. Type answers in provided spaces and boxes. Use colored text for your written answers. Create tables for data (organize in rows and columns) within the boxes.
3. Keep text boxes with the questions they pertain to (drag and move them as necessary).
4. Insert screenshots to illustrate results. Write a brief figure legend for each screenshot.
5. Complete Exercises 1-3 and save as a pdf. Upload to Canvas by INSERT DATE.
6. Have your results available to share and discuss with the class.
7. Complete Exercise 4 and save entire project as a pdf. Upload the complete document (all exercises, results, and answers to questions) to Canvas by INSERT DATE.

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The following exercises use Avida-E D ([https:// https://avida-ed.msu.edu/app4/](https://avida-ed.msu.edu/app4/)).

**Introduction**

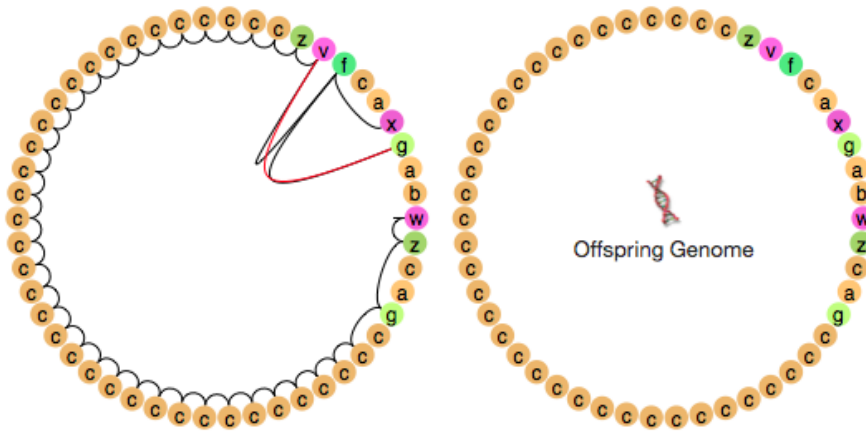
Figure 1 presents a standard genome for a digital organism called **Avidian**. This genome has 50 sets of instructions (you can think of them as genes) for performing various essential functions, which ultimately allow an Avidian to survive (by accessing resources in its environment) and replicate itself. Each instruction set (gene) is represented by a particular letter in the English alphabet and by its position in the genome. The letter c in position #6 (c6) does not code for the same instructions as c10. There are 26 different types of instructions (alleles) at each position (for each gene). For example, position #8 (gene 8) can have instruction set (allele) a, b, c, etc.

**Figure 1.** Avidian genome may be represented graphically as a circle (plasmid) or as a linear strand. Each letter at its orderly position represents a unique set of “genetic” instructions.



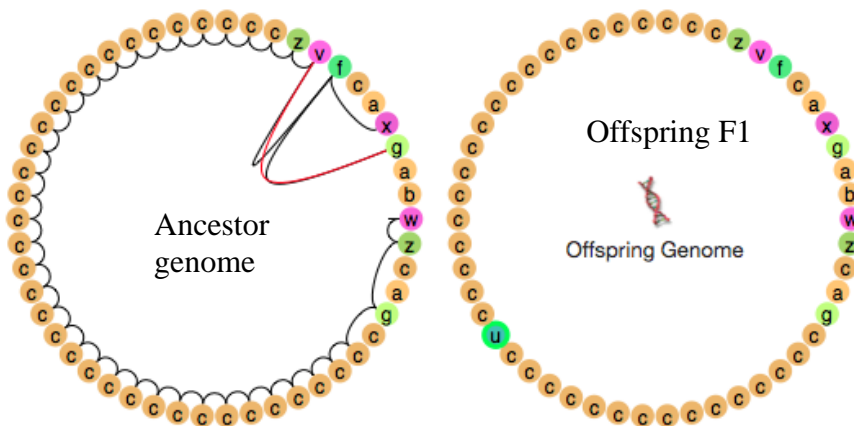
Similar to living organisms, Avidians generate progeny by first replicating their genome.

**Figure 2:** Genomes of Avidians following replication. The ancestor/parent genome is on the left, and the replicated genome that represents an offspring is on the right.



Avidian genomes are subject to random mutations, just like the genomes of living organisms. Thus, if a letter “c” at position #10 (starting from “w”), is replaced by any other letter, that means that there is a particular mutation at position 10. That means a new set of instructions resulting in the organism’s genome changing its **genotype** and producing a modified **phenotype**.

**Figure 3.** Genomes of two Avidians: an ancestor and its offspring F1 – first generation.



**Exercise 1:** Build a library of organisms that consists of the ancestor and three different F1 offspring of the original ancestor. Offspring should be different from the ancestor and from each other with respect to their genotype (i.e., have difference sets of “alleles”) and be able to replicate. Record the names of the offspring below and state how each offspring is different from the ancestor.

NAME	Difference(s)
1. _____	
2. _____	
3. _____	

**Exercise 2a.** We will seek answers to the following questions: (1) Does the average fitness of a population change over time when no mutations take place? (2) Does the average fitness of a population change over time when mutations happen? (3) How does the energy acquisition rate relate to evolutionary fitness?

Select your predictions with respect to average population fitness in the table below. Then use the ancestor organism and one of the F1 offspring to test your predictions.

**Predictions**

Organism	No new mutation	Mutation rate at 2%
ancestor	1) no change____ 2) increase over time ____ 3) decrease over time ____	1) no change____ 2) increase over time ____ 3) decrease over time ____
offspring name here	1) no change ____ 2) increase over time ____ (____ same as ancestor; ____higher than ancestor) 3) decrease over time ____ (____ same as ancestor; ____lower than ancestor)	1) no change ____ 2) increase over time ____ (____ same as ancestor; ____higher than ancestor) 3) decrease over time ____ (____ same as ancestor; ____lower than ancestor)

- Setup your ecosystem to 0% mutation + all resources available. You should run the experiment for at least 1000 updates.
- Click Map to return to the ecosystem. Place the ancestor into the ecosystem.
- In the dropdown menu for **Mode**, select Fitness.
- The ancestor organism’s starting fitness value = 0.25, energy acquisition rate = 47.00, and offspring cost = 189.00. You can check that by clicking <Run>, and immediately <Pause> (you should still have only 1 organism in the ecosystem). Click on the organism, and confirm its stats in the **Selected Organism Type** window.
- Click Run.
- You can watch for real-time changes in the values of interest by observing the graph in the lower right edge of app’s display; select the value to observe in the dropdown menu.
- Use the **Populations Statistics** window to obtain and record the final values for the average population fitness and energy acquisition rate at the end of 1000 updates. Compare to the initial values of the ancestor.

- Repeat the above for your choice of F1 offspring. Make sure to adjust the Setup for 0% mutation rate and run for 1000 updates.
- The offspring's initial stats may be different from its ancestor. Once you place the offspring in the ecosystem, click <Run>, and immediately <Pause>. Then click on the organism, and confirm, then record its stats in the **Selected Organism Type** window.
  
- Now setup the ecosystem for 2% mutation rate.
- Repeat the evolution runs for the ancestor and the F1 offspring.
- Record the values and check the results against your predictions.
- How do the average population fitness and energy acquisition rate graphs and values compare? Discuss.

**Comment on your results.**

Put your results, comments, and discussion here.

**Exercise 2b:** Repeatability. Run each of the experiments above 5 times. Do you get the same results? Why or why not?

Put your results and discussion here.

**Exercise 3:** Competition. Now put two different organisms into your petri dish ecosystem.  
Organism names:

1. \_\_\_\_\_

2. \_\_\_\_\_

Predict what you think will happen as the organisms compete under conditions of evolution (i.e., allowing for mutations).

Prediction here

Using the 2% mutation rate, run the simulation for at least 1000 generations. Repeat the simulation 5 times. For each run, record population values of energy acquisition rate and fitness.

Also, look at the population statistics at the top right. If you get organisms that can use the extra energy sources, save them to the freezer with appropriate names. How do you think this is related to the average population energy acquisition rate and fitness values?

Discuss your results.

Put your results and discussion here.

**Exercise 4:** Design an experiment to test the evolution of a population of organisms that varies in its ability to use different energy sources.

Hypothesis (present tense statement that describes a causal relationship) & Prediction (future tense statement that states the specific outcome of the experiment if your hypothesis is true)

Hypothesis and Prediction here.

Set-up information

Put important information about the parameters of your experiment here.

Results

Describe your results here.

Discuss what your results mean in terms of the evolution of the population.

Discuss the evolution of your population here.