ACTIVITY: Survival of the Sweetest

AP Biology

Natural selection is sometimes referred to as “survival of the fittest.” For example, in an arid environment narrow leaf plants survive at a greater rate than broad leaf plants. The narrow leaf plant conserves water much better than the broad leaf plant. It is important to note that individual organisms do not adapt to their environment. Rather, they possess traits that make them better suited for survival and ultimately afford them a reproductive advantage.

The struggle for existence does not only shape the traits of a population but also shapes communities. Competition for finite resources and predation both determine the size and diversity of a community. The relationships of the species in the community are often more complex than they first appear with some species having a disproportionate effect on their environment.

PURPOSE

In Part I, you will simulate the events of natural selection for a population of mussels living in the rocky, intertidal zone of the Pacific Ocean. Mussels are bivalves much like clams and oysters. This simulated population of mussels (Peloris dulcis) has individuals with thick, strong shells and others with thin, weak shells. The thick shell provides more protection from the predaceous starfish lurking in the shallows. The starfish more readily eats the mussels with the thin shells. Orange and yellow candies will represent the variation found in this species of mussel.

In Part II, you will simulate the effects of a predaceous starfish on the diversity ofa community made up of barnacles, mussels, chitons, and snails. It is important to point out that each candy color represents a different species, not variations within a species as modeled in Part I. You will also simulate the effects of removing the predaceous starfish on the diversity of the community. In addition, each species is competing for limited space. Competition can force some species out of the ecosystem.

PROCEDURE

PART I

1. Obtain the population of candy “mussels” (Peloris dulcis) from your teacher. This bag should contain equal numbers of yellow and orange candies. As the predator, you prefer to eat the yellow mussels with thin shells rather than the thicker shelled orange ones.
2. Formulate a hypothesis regarding what will happen to the ratio of yellow to orange mussels knowing the predator’s preference. Record your hypothesis in the space provided below.

   Hypothesis:

3. Establish the first generation by having one partner reach in the bag and, without looking, randomly select 10 mussels.

4. Place the 10 mussels on the graph paper serving as the rocky shoreline found at the end of this lesson. This represents the initial population of mussels. Count the number of yellow and orange mussels present. Record your numbers for Generation 1 in Table 1 Below.
5. Simulate predation by choosing three yellow mussels from the rocky shoreline and eating them. Remember that you are the predaceous starfish, and you prefer to eat the yellow mussels first. If you only have one or two yellow mussels, eat them first and then consume enough orange mussels to meet your quota. For example, if you have only one yellow mussel, eat it and then two orange ones. If you have two yellow mussels, eat both of them and one orange mussel.
6. To simulate reproduction in the population, close your eyes, reach into the bag, and choose three mussels to add to your rocky shoreline. This should bring your total number of mussels back to 10.
7. Record the number of yellow and orange mussels that are now present in the population in the space for Generation 2 in Table 1.
8. The other partner should now take a turn at being a predator. The predator should eat three yellow mussels from the rocky shoreline. If there are not three yellow mussels, follow the procedure described in Step 5.
9. Simulate reproduction in the population by repeating Step 6. Count the number of each type of mussel in the population, and record this data in space for Generation 3 in Table 1.
10. Repeat this process detailed in Step 5 through Step 9 until you have a total of five generations of data.

Table 1: Generation of Yellow and Orange Mussels

Generations	Yellow Mussels	Orange Mussels
1		
2		
3		
4		
5		

Intertidal Food Web

11. As instructed by your teacher, combine your individual data with the class data for each of the five generations. Calculate the class average for each mussel for each generation. Record class averages in Table 2 of the Analysis section.

Table 2: Generation of Yellow and Orange Mussels (Class Averages)

Generations	Yellow Mussels	Orange Mussels
1		
2		
3		
4		
5		

PART II

We will model the effects of a predator on the diversity of a community. Many communities have species with larger than expected effects on their environment. Biologists refer to these as keystone species.

The keystone species in this model is a large, predatory starfish. Other members of the community include barnacles, mussels, chitons, and two types of snails (one carnivorous, the other herbivorous). The starfish preys upon all five species. The carnivorous snail eats both mussels and barnacles. Each species competes for the limited space along the rocky shoreline.

red candy pieces	carnivorous snail	
orange candy pieces	mussel	
yellow candy pieces	barnacle	
green candy pieces	chiton	
violet candy pieces	herbivorous snail	

Figure 1: Marine community species

1. Illustrate a food web representing the feeding relationships described above in the space provided on the student answer page.
2. After considering the illustrated food web, formulate a hypothesis predicting the abundance of the five-prey species if the predatory starfish is removed from the environment. Record your hypothesis in the space provided below.

   Hypothesis:

3. Obtain the candy "marine invertebrates" from your teacher. This bag will contain the items described in Figure 1. You will serve as the predatory starfish.
4. Select 25 organisms (candy pieces) at random and place them on the graph paper serving as the rocky shoreline found at the end of this lesson. Each organism must be placed on a gray, numbered square within the outline of the rocky shoreline. Always place the red snails first (start with number 1). Next, place the orange mussels, then the yellow barnacles, then the green chitons and, finally, the violet snails (all in numerical order). Although the mussel, barnacle, chiton, and herbivorous snail do not eat one another, they do compete for available space. If one of the more competitive species quickly reproduces, it will push the other populations out of the ecosystem.
5. Count the number of each type of organism and record the data in the space marked Initial Population for Generation 1 in Table 3.
6. Using the Feeding Chart located elsewhere in this lesson, roll the die once to determine the next meal of the starfish (round up if there is half of a prey item). The choices of the starfish are found on the inner ring. Remove the organisms (candy pieces) consumed by the starfish.
7. Roll the die a second time to determine the action of the carnivorous snails. The choices of the carnivorous snail are located on the outer ring of the Feeding Chart. Remove a carnivorous snail, mussel, or barnacle as determined by your roll.
8. Once you have rolled the die twice and removed the organisms consumed, record the final population of each species in the space marked Final Population for Generation 1 in Table 3.
9. Before the next round, the organisms will reproduce. Use the following rules to determine the correct number of each species after reproduction:
   a. The orange mussels will double their number
   b. The yellow barnacles, green chitons, and violet herbivorous snails will add one organism for every two individuals present (do not round up)
   c. The red carnivorous snails will add one organism for every four individuals present (again, do not round up)
   d. If one of the populations does not meet the requirements for reproduction, add one individual to that population.

   Example: After Generation 2, there are three red carnivorous snails in the final population. According to (c), you must have at least four red carnivorous snails to reproduce; however, (d) states that you always add at least one individual to the population. Therefore, your initial population of red carnivorous snails for Generation 3 will be four.

10. After adding the appropriate number of individuals, record the new population in the space marked Initial Population for Generation 2 in Table 3.
11. Following the sequence established in Step 4, place the red snails first, then the orange mussels, then the yellow barnacles, then the green chitons and, lastly, the violet snails (all in numerical order). If there is not enough room to place all of the individuals, adjust the bottom population of the species that is "crowded out."
12. Repeat Step 6 through Step 9 to simulate events through Generation 4. Record your data in Table 3.
13. The starfish is now removed from the ecosystem. After Generation 4, you will only need to roll the die once to determine the actions of the carnivorous snails. Continue to follow Step 7 through Step 9 (with only one die and using the outer ring of the Feeding Chart) to simulate events through Generation 10. Record your data in Table 3.

Table 3: Population of Each Species per Generation

Table 3. Population of Each Species by Generation

	Generation 1		Generation 2		Generation 3		Generation 4			
	Initial	Final	Initial	Final	Initial	Final	Initial	Final		
Red carnivorous snail									Remove Starfish	Continue with Generation 5
Orange mussel										
Yellow barnacle										
Green chiton										
Violet herbivorous snail										

Table 3. Population of Each Species by Generation (continued)												
	Generation 5		Generation 6		Generation 7		Generation 8		Generation 9		Generation 10	
	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final
Red carnivorous snail												
Orange mussel												
Yellow barnacle												
Green chiton												
Violet herbivorous snail												

ANALYSIS

1. Prepare a graph of the class averages of orange and yellow mussels for each generation. Be sure to include axes labels, units, and a title on your graph.

2. Prepare a graph of the orange mussels for each generation (final generation). Be sure to include axes labels, units, and a title on your graph.

CONCLUSION QUESTIONS

PART I

1. You are given the following question for part 1: Do the numbers of orange and yellow mussels change over five generations? Write a claim statement describing how the number of yellow and orange mussels changed over the five generations.

2. Provide evidence for your claim:

3. Provide the scientific concept explanation of the data to support your claim using the evidence.

4. Predict what would happen to the number of yellow mussels if you continued predation for a total of 10 generations. Justify your prediction.

5. According to Darwin's Theory of Natural Selection, predict which type of mussel would be the most fit? Justify your prediction.

6. What adaptations do these mussels possess that allows them to survive?

7. Explain why it is incorrect to say an individual adapts and evolves to its environment?

PART II

1. Which organism possesses traits that enable it to exploit the rocky shoreline more efficiently than the other populations in the community? Explain.

2. Compare the change in diversity of the community in Generation 1 to Generation 10. Identify and describe TWO major factors that accounts for this change?

3. Consider the following hypothesis of Robert Paine. "Local species diversity is directly related to the efficiency with which predators prevent the monopolization of the major environmental requisites (necessities of life) by one species". Does your data support or refute this hypothesis? Explain using your data as evidence from Generations 1 through Generation 10.

AP Extension:

1. Provide Two Graphs:
    a. Each initial population vs. time (all on the same set of axes)
    b. The column graph that visually depicts how the community composition changed vs. time

2. Describe at least three interactions occurring within this community and tell me how these interactions work together to determine the structure of this simulated intertidal community.

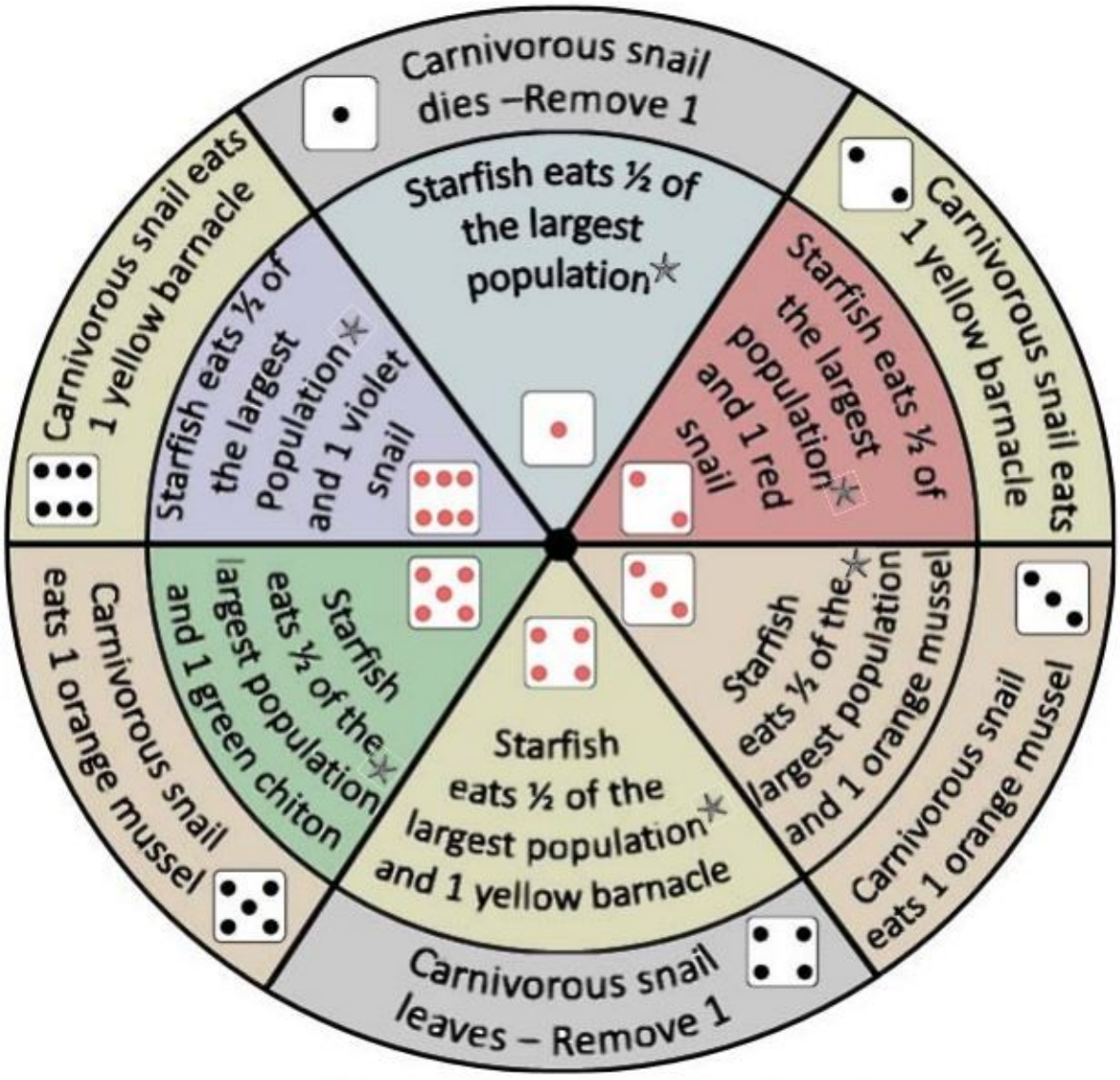
3. Does the starfish regulate community diversity in this system? What evidence do you have to support your claim? How does the starfish regulate community diversity, and why did its action influence habitat availability for other organisms?

4. The starfish is considered a keystone species (specifically, a keystone predator). What is a keystone species? Define it. Now, consider this “menu of keystone species”: otters, gopher tortises, Grey Wolves, African Elephants, Prairie Dogs, grizzly bears. Pick one of these organisms and…
    a. Describe their habitat/ecosystem/community
    b. Describe their activity within the community and tell me how this activity maintains diversity in the community
    c. Describe what happens when the keystone species is removed.
    d. Describe any unintended consequences of the removal of the keystone species.

    You can build a flow chart to describe all this, or if you write a narrative, you can augment your discussion with a “story board” or “comic strip”.

Deliverable:
With your partner produce a Google Doc, Google Slides or in your BILL your data and analysis of activity. Then submit with your partner on Google Classroom.

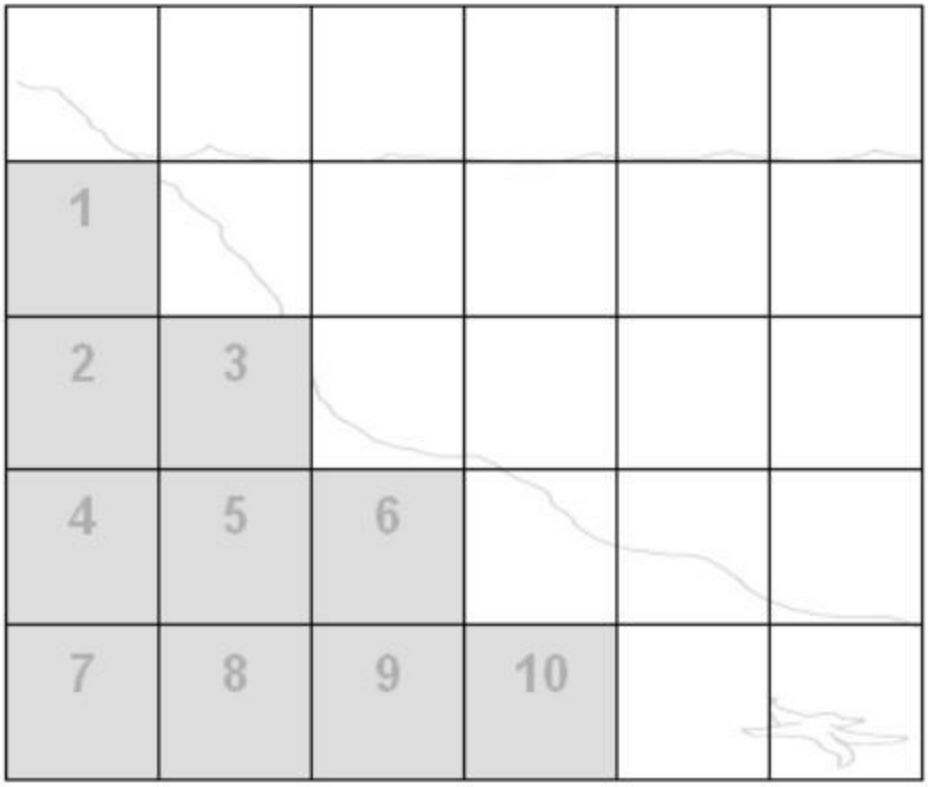
Item #1 – Feeding Chart



★ If multiple populations are the same size, choose the species highest on the shoreline (towards 1) to consume

1. **Determine the starfish's next meal by rolling one die.**
2. **Select the corresponding section from the inner circle.**
3. **Remove the organisms indicated.**
4. **Determine the carnivorous snails' actions by rolling one die.**
5. **Select the corresponding section from the outer circle.**
6. **Remove the organisms indicated.**
7. **Before the next roll, make sure you follow the procedure for adding new members to the community**

Item #2 Shoreline Models



Item #2 Shoreline Models