Oyster Morphs:
Adaptations to the Environment

Grade level: 3 – 12
Subject: Life Science/biology
Duration: 60-90 minutes (in 30-45 minute intervals)
Group size: up to 30 students
Setting: Classroom or Playground

OVERVIEW

This activity will allow students to actively demonstrate how organisms have adapted to their environment. This activity can be modified to grades 3-12, depending on the level of analysis performed on the results.

CONTENT STANDARDS

California Science Content Standards for Public Schools
Life Science: Grade 3 – 3a,d,e; Grade 4 – 2a,b,3b,6a,c,d,e,f; Grade 5 – 5e; Grade 6 - 5a,b,c,e; Grade 7 – 3a,b,7c,e; Grade 8 – 9a,b; Grades 9-12 – 6a-d,g; 7a,c,d; 8a,b

PEFORMANANCE OBJECTIVES

The students will be able to:

- experience the difficulties faced by organisms in their environment as they try to compete for food and survive as predators;
- understand how climate change, illness, and mutations may alter an organism's role and success in an environment;
- understand the concept of natural selection and how variation within a population is the 'raw material' of natural selection;
- demonstrate how organisms that are best adapted to capture prey will be able to survive and reproduce; and
- demonstrate how different types of prey are able to survive because of particular characteristics.

Students at higher levels will be able to formulate hypotheses, compile and analyze data.

TEACHER BACKGROUND

Adaptations to one's environment
Variations occur spontaneously within a given population (a stable group of interbreeding organisms). Certain individuals in any population are more aptly equipped or better adapted in some ways to obtain food than other individuals. The individuals with characteristics that increase their capacity to obtain nutrients, escape predators, withstand adverse climatic conditions, or attract mates, will have a better chance of surviving and reproducing. Inheritable variations (those that occur in the genetic material, and thus can be passed on to the offspring), give an organism an improved chance of surviving and reproducing (and thereby leaving more viable offspring than other individuals leave behind) are called **adaptations**.

The interactions between an organism and its environment and also the interactions between organisms within an environment occur constantly in all ecosystems. This activity will focus on the marine ecosystem, in particular the role of filter feeders. Organisms such as bivalves (e.g. oysters, clams, mussels, etc.) are filter feeders that live on or in the **benthos** (bottom sediments and associated organisms). These animals flush seawater over specialized gills that catch particles of algae for food. Some species of whales, such as the blue whale, are also filter feeders, and can swallow huge amounts of seawater, filtering out **zooplankton** (small animals that live suspended in the water column) through sheets of specialized structures known as baleen. These organisms have succeeded in their respective environments because they have adapted to catch and eat the food they need through the specialization of their filters.

Basic Oyster Biology/Ecology

Pacific Oysters (Phylum: Mollusca, Class: Bivalvia, Order: Ostreoida, Family: Ostreidae, Genus: *Crassostrea*, Species: *C. gigas*) are **bivalves**, a group of organisms that have two shell halves and are part of the Phylum Mollusca. The native oyster of the Pacific coast of Korea, Japan and China, has been introduced as an aquacultural product to North American (primarily Puget Sound, Washington) and to the Australian states of Tasmania and South Australia. It is an important commercial harvest in all of these places.

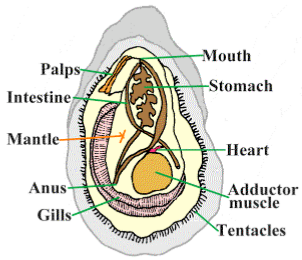
General

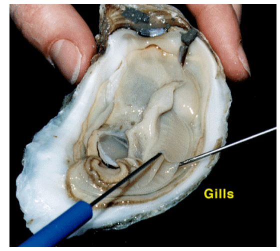
Adult oysters are sessile benthic animals, meaning they are non-moving and live on the seafloor. The larvae are planktonic. They are common in shallow water and intertidal environments, but some species also inhabit deeper waters. Oysters feed by passing seawater and all of its goodies over their gills (see diagrams below), which then catch the particulates (more details below).

Oysters are important to marine ecosystems because of their ability to filter up to 50 gallons per day, removing phytoplankton (single-cell algae that live suspended in the water column) and other particulates from the seawater. They are responsible for keeping entire bodies of water clear and their ecosystems working properly. Many years ago, the Chesapeake Bay was filled with oysters and a very healthy ecosystem. Over the years, exploitation of the oyster stocks by people left the Chesapeake Bay unfiltered, murky, and devoid of the diversity and wealth of life that was once there. Oysters are a very popular delicacy in many countries, including the U.S. Due to the high demand, the practice of oyster farming has become a large industry in the U.S., and growing rapidly. The Pacific Oyster is the most heavily farmed species of oyster in the world, which is why a lot of research is focused on its biology, ecology and genetics.

Feeding Biology

Oysters feed by passing seawater and all of its goodies over their gills (see diagrams below), which catch the particulates. The gills are the largest organ in the oyster's body and consist of four folds of tissue. Along with the mantle, it is the chief organ of respiration. It also is able to create water currents, collect food particles and move food particles down to the labial palps for sorting. What happens is that when phytoplankton (and other particulates) are filtered through the gills, they are entrapped and bound in mucus. Strings of mucus carry the particulate matter to the labial palps, where it is sorted and either passed into the mouth, or rejected as **pseudofeces** (these are so named because while they are waste from the oyster, they have not passed through the gut). While some gills are able to catch particles that are 2 microns in size (one micron is 10^{-6} meters), most gills catch particles that range from 3-10 microns in size. This is the size of many single-celled phytoplankton species.





MATERIALS NEEDED

For the **entire class**:

To represent different plankton types:
1. 5-6 large sponges, cut into specific shapes (see set up)

One for **each student**:

1. Plastic cup
2. Pencil
3. Calculator & graphing paper (grades 7-12 only)
4. One copy of **Table 2&3** (grades 7-12 only)

One for **every group** of 5-6 students:

1. One copy of **Table 1** (grades 3-6) or **Table 2&3** (grades 7-12)
2. Two of each to represent different feeding structures:
   a. Small-screened metal strainers *(gill type I)*
   b. Slotted spatulas *(gill type II)*
   c. Large serving forks *(gill type III)*
3. One large tub filled with water to represent the aquatic environment

SET UP

Each student will represent a certain oyster morph, indicated by his or her feeding structure (gill type). They will pair up with another individual with the same gill type, and form a group with 2 other pairs of different gill types, forming a small population of 5-6 students. Each individual oyster morph will have a plastic cup (mouth) in which to store the 'food' they're filtering. This adds to the challenge because the students have to 'ingest' their food before getting more!

1. There will be 3 different plankton types that will be of different sizes and shapes. Some of the plankton types will sink, while others may float. To make floating plankton, cut sponges into pieces that are of varying sizes or shapes. These will represent different plankton types. The sizes should be in a range so that only 1 or 2 of the oyster morphs can catch it in its gill type (slotted spatula, metal strainer, or serving fork).

2. Fill a large tub with water and distribute equal and known quantity of each plankton type into the water (depending on the size of the tub, 15 of each). Mix well to evenly distribute. The tubs can be used in the classroom, or outside to make it easier on clean up.

VOCABULARY

- **Bivalves** – a class of organisms with two shell halves that belong to the phylum Mollusca, and include mussels, clams, and scallops.
- **"Morph"** – different genotypic or phenotypic variations of a specific organism

- **Plankton** – organisms (algae or animals) that live suspended in the water column and drift with water currents
- **Population** – a stable group of interbreeding individuals
- **Variation** – a deviation in characters in an individual from those typical of the group to which it belongs, also, deviation in characters of the offspring from those of its parents. For example, different color hair, different heights, different gills lengths, ability to filter more sizes of plankton.

PROCEDURE

Discussion:

1. Discuss the concept of adaptations to all levels. Higher levels will just need a brief review on this subject, but this will be the central concept for the elementary students. Have students offer some simple examples of adaptations organisms have to survive in their surrounding environment.

2. Introduce the students at all levels to filter feeders and their role in the marine ecosystem. What foods do they eat, how do different types of organisms differ in their prey and feeding equipment? Concentrate on bivalves, highlighting the oyster and their feeding apparatus (see teacher background). However, do point out that large animals such as humpback whales are able to sustain their feeding needs through filter feeding.

   Higher levels (grades 7-12): Discuss natural selection. Explain how genotypes differ from phenotypes, and how there can be variation in either, or both. Explain how this natural variation within a population is what eventually leads to natural selection, as phenotypes that aren't adapted optimally to their environment may not survive to reproduce and are weeded out of the population. Make sure that students understand that in order for an organism to be considered successful, they must not only survive to maturity and reproduce, but their offspring must also survive and reproduce themselves.

3. A related topic to natural selection is that of genetic mutation. Mutations that occur by chance in an organism's genes can lead to variations in the phenotypes that can be either beneficial or detrimental (even lethal) to their survival. The occurrence of mutations allow for another cause of variation within populations, adding to the potential for adaptation and shifts in a population's make-up.

4. After explaining how the activity will work and showing your students the different types of prey (sponges, etc.) and predators (utensils), have your **7th-12th grade** students make predictions/hypotheses based on their observations of these items about the survival of the prey (different plankton types) and the predators (different oyster morphs). Which predators might be the most successful (eat the most plankton and survive to reproduce) and least successful? Why? Which prey will be eaten up first and which will survive the longest (the most number of rounds)? Why?

Activity (all grade levels):

1. Depending on size of class, divide the students into numerous sets of 'populations' (5-6 individuals), each with their own tub. At least three different gill types should be represented in each population. Each student is given the feeding structure of their assigned oyster morph and a mouth

(plastic cup). Higher levels make sure to record the original number of plankton that go into your tub on your data sheet.

2. Students will gather around the tub and wait for your cue to begin 'feeding' in Round 1. When you give the signal, students will have **1 minute** to gather up as much of the different plankton types they can and place them in their mouth.

   Optional rule for higher levels: Each student must only make one sweep with their feeding apparatus at a time, and then empty their 'filters' into their mouth. This simulates eating and the differing abilities of different organisms to assimilate their food. Most bivalves will filter a large amount of water, but can only actually eat and assimilate a certain proportion of the particles they filter. What they don't consume is balled with mucous into what are called **pseudofaeces** and discarded before entering the digestive tract. This is an important part of feeding ecology of these animals that can be addressed by adding this rule and discussing how it affected the different oyster morphs' ability to consume plankton. Lower levels do not have to adhere to this rule, as it may be too advanced a concept for them.

3. After Round 1, the students will count the amount of plankton they have consumed (only the plankton that is in their mouth by the end of the minute. If they have plankton in their tool, but not in their mouth, have them return it to the tub - it is pseudofaeces!).

4. Enter data for Round 1:

   Lower levels (grades 3-6):

   Using **Table 1**, enter the amount and types of plankton consumed for each oyster morph (see teacher's example if needed). Once the students have tallied their plankton, have them set aside items *(do not place back into tub)*, and prepare for the next round. Repeat steps 2-4 for Rounds 2-3 (depending on how much time you have and/or how much plankton is left). Each round from beginning to the next round (i.e. including tallying of plankton) should take about 10 minutes. The activity itself should be able to be completed in one class period-you can use the next class period to analyze the results and discuss them with your class. **Skip down to analysis for lower levels.**

   Higher levels (grades 7-12):

   Using **Table 2,** enter the amount of the different types of plankton consumed (see teacher's example if needed). Each different population will complete one table. Each oyster morph will tally how many of each plankton type was consumed, then find the total plankton consumed. The pair of oyster morphs with the same gill type will then add together their totals, and then find the average consumption per gill type. This number signifies the minimum amount of plankton that needed to be consumed in order for an individual of that oyster morph to survive. Students that have that amount or greater have survived until the next round (it should be only one individual, unless they have the exact number and then they both survive). Indicate which individual survives to the next generation on the table. The individuals that do not survive the first round do not participate in the subsequent rounds.

   Each plankton type will also be monitored at each round. Using **Table 3**, subtract the amount of a particular plankton type that was consumed from the original population and the remaining number is the surviving population. Put this new number down as the population # for the next generation. This number will also be the number that goes in the next round's 'Starting Population' box on the table (see teacher's example if needed). Now have each surviving plankton type reproduce one individual of the same type. Add the appropriate amount of each plankton type to the tub to bring the population up to the new size for Round 2.

Continue to Round 2 (second generation). Once again, individuals compete for plankton for **1 minute**. Students tally individual totals, population totals, and take the average of the population (all morphs combined). Those individuals that have consumed the average amount or greater have survived to a third generation (Round 3), and the plankton reproduce (add more to the tubs). Continue for a third round, and determine the fittest individual oyster morph of each population. If given enough time, have survivors from each population compete in one tub for a final round.

ANALYSIS AND CONCLUSION

Lower levels (grades 3-6):

1. Total the amount of each plankton type consumed by the different oyster morphs for every population, and divide that number by the total number of populations to find the average for each oyster morph. Record the average numbers on the board or an overhead for all the class to see. You can then construct a graph (a bar graph) to display the results of each oyster morph and shows the type of plankton each morph was best adapted for capturing.
2. Discuss why certain plankton types were consumed more quickly than others in relation to their characteristics (e.g. bigger plankton could be caught by more oyster morphs, so their numbers decreased faster), and also why certain oyster morphs succeeded in capturing more than others due to their characteristics (e.g. the small metal strainer caught the most prey because it had the smallest sized filters).
3. Discuss how adaptations such as the ones demonstrated though this activity are vital to individual species survival in the natural environment.

Higher levels (grades 7-12):

1. Have each of the students record the results of their population from **Table 2&3** onto a copy of their own tables. Have them create line or bar graphs of both the oyster morph and the plankton type changes over generations. As in the lower levels, they should see changes in the different morphs over time.
2. Have a representative from each population come up and draw their graphs on the board so you can compare population to population. Discuss the general trends in oysters and plankton types over time. Discuss similarities and differences between populations and why they might occur.
3. Discuss what would happen if the surviving oyster morphs from each round were able to reproduce and have a greater number of those morphs in the environment. What would happen then? Perhaps some populations would remain steady, others decline, and others might increase. Or it may be a case where some oysters declined at first, but then began to increase in later generations. Discuss the fact that while some adaptations that an organism is born with are inherently beneficial or detrimental, individuals do have the ability to learn how to use their tools and improve on their hunting techniques over time.
4. Have students write up the experiment as a report, including tables and graphs.

OPTIONAL ADDITIONS TO ACTIVITY

NOTE: you may need extra materials for this part. See below.

Before each round, one student from each oyster morph type or population can pick a 'wild card' (you can make two piles-one for individuals, one for population sized events) that may depict situations that may occur in an oyster's natural environment. For instance:

> "Toxic algal bloom has occurred. Half of your population has died because your oyster morph eats that particular species of planktonic algae."
>
> "El nino year occurs where water currents are changed and the plankton of (blank) type does not bloom. Take that plankton type out of the tub."
>
> "You have a mutation that only allows you to use half of your feeding structure. Obtain a modified tool of your morph from your teacher." (You can cut the tools in half and give them to the afflicted student)
>
> "You have a mutation that has doubled your feeding structure size. Obtain a second tool of your gill type from you teacher and tape your two tools together."

You can have either environmental or genetic events occur at the individual or population level and the students can see how these changes may affect their performance from one round to another. This activity can be modified at any level to become more or less complex simply by adding or subtracting steps outlined above.

Additional materials to be provided

- Analysis tables for lower and higher levels
- Example graphs for each level on possible results and how to show data.

TABLE 1 - 1st Generation of Captured Prey (student worksheet)

First Generation	Prey Types- Number Eaten			Total Prey Consumed
Predator Type	1	2	3	
Gill Type A I				
Gill Type A II				
Gill Type B I				
Gill Type B II				
Gill Type C I				
Gill Type C II				

TABLE 1 - 2nd Generation of Captured Prey (student worksheet)

Second Generation	Prey Types- Number Eaten			Total Prey Consumed
Predator Type	1	2	3	
Gill Type A I				
Gill Type A II				
Gill Type B I				
Gill Type B II				
Gill Type C I				
Gill Type C II				

TABLE 1 - 3rd Generation of Captured Prey (student worksheet)

Third Generation	Prey Types- Number Eaten			Total Prey Consumed
Predator Type	1	2	3	
Gill Type A I				
Gill Type A II				
Gill Type B I				
Gill Type B II				
Gill Type C I				
Gill Type C II				

TABLE 2 - 1st Generation of Captured Prey (teacher's example)

First Generation	Prey Types - Number Eaten			Total Prey Consumed	Average # Prey per Individual	Survived?
Predator Type	**1**	**2**	**3**			
Gill Type A I	4	3	6	20	18	Yes
Gill Type A II	3	5	5	17	18	No
Gill Type B I	2	2	0	4	5	No
Gill Type B II	2	3	1	6	5	Yes
Gill Type C I	1	1	0	2	1.5	Yes
Gill Type C II	1	0	0	1	1.5	No

TABLE 2 - 1st Generation of Captured Prey (student worksheet)

First Generation	Prey Types - Number Eaten			Total Prey Consumed	Average # Prey per Individual	Survived?
Predator Type	1	2	3			
Gill Type A I						
Gill Type A II						
Gill Type B I						
Gill Type B II						
Gill Type C I						
Gill Type C II						

TABLE 2 - 2nd Generation of Captured Prey (student worksheet)

Second Generation	Prey Types - Number Eaten			Total Prey Consumed	Average # Prey per Individual	Survived?
Predator Type	1	2	3			
Gill Type A I						
Gill Type A II						
Gill Type B I						
Gill Type B II						
Gill Type C I						
Gill Type C II						

TABLE 2 - 3rd Generation of Captured Prey (student worksheet)

Third Generation	Prey Types - Number Eaten			Total Prey Consumed	Average # Prey per Individual	Survived?
Predator Type	1	2	3			
Gill Type A I						
Gill Type A II						
Gill Type B I						
Gill Type B II						
Gill Type C I						
Gill Type C II						

TABLE 3 - Phytoplankton Prey (teacher's example)

First Generation	Prey Type 1	Prey Type 2	Prey Type 3
Starting Population	15	15	15
Number Killed	13	14	12
Population of Next Generation	2	1	3
Second Generation	**Prey Type 1**	**Prey Type 2**	**Prey Type 3**
Starting Population	2	1	3
Number Killed	2	1	3
Population of Next Generation	0	0	0
Third Generation	**Prey Type 1**	**Prey Type 2**	**Prey Type 3**
Starting Population	0	0	0
Number Killed	X	X	X
Population of Next Generation	X	X	X

TABLE 3 - Phytoplankton Prey (student worksheet)

First Generation	Prey Type 1	Prey Type 2	Prey Type 3
Starting Population			
Number Killed			
Population of Next Generation			
Second Generation	**Prey Type 1**	**Prey Type 2**	**Prey Type 3**
Starting Population			
Number Killed			
Population of Next Generation			
Third Generation	**Prey Type 1**	**Prey Type 2**	**Prey Type 3**
Starting Population			
Number Killed			
Population of Next Generation			