Barnacles: Still Hanging On

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Key Concepts

1. Many species of barnacles live in intertidal area and are particularly well adapted to endure the stresses of long exposure at low tide.

2. Barnacles extend their cirri and move them through the water to absorb oxygen and collect food.

3.Cirri movements vary with environmental changes.

4. Barnacles are hermaphroditic, reproduce sexually and go through planktonic larval stages before attaching to hard surfaces.

Background

Barnacles are one of the most common rocky shore intertidal marine animals. There are species of barnacles living in all intertidal zones, some are subtidal and some even live on whales. Some barnacles are parasitic and look so different from their free-living barnacle relatives that they were only found to be barnacles because of the presence of a typical barnacle cypris larva stage. But perhaps the most amazing barnacles are those that live in the upper intertidal zones, submerged only for a short time during each tidal cycle. Their endurance is remarkable.

Their adaptations for intertidal life also make them excellent laboratory animals. With just a little care, they can survive some handling in the laboratory and some manipulation of environmental conditions.

Barnacles also make an excellent animal for experimentation because their behavior of moving their cirri through the water is easy to count and changes when environmental conditions change. At the same time, different barnacles can have different behaviors and one barnacle's behavior can change unpredictably. This makes them varied enough to stay interesting. Students will be fascinated watching the movements of the complex animal hidden inside the tiny, ubiquitous barnacle shells.

Materials

Part 1

For each student or pair of students:

- 1 clump of live barnacles
- 1 fingerbowl
- 1 thermometer
- watch or timer or clock with a second hand
- cool saltwater (5-10° C) or ice in large dishes to form an ice bath
- warm saltwater (15° - 20° C)
- "Barnacles" student pages

NOTE: the cool and warm water should have a temperature difference of 10° C or more.

Part 2

For each student of pair of students:

- one clump of live barnacles
- fingerbowls
- saltwater
- dissecting microscope
- live plankton or brine shrimp or fine fish food
- eye dropper (or a stirring rod if using fish food)
- food coloring
- "Barnacles" student pages

Part 3

For each student or pair of students:

- one clump of living barnacles
- fingerbowl
- fine mesh nylon cloth or plankton net
- dissecting or compound microscope
- "Barnacles" student pages

Teaching Hints

"Barnacles: Still Hanging On" requires living barnacles, either collected from a local beach or purchased from a scientific supply company. Please check the laws governing collection of barnacles and other invertebrates before collecting. Many states require permits, most often available from the State Department of Fisheries. It is probably easiest to collect small rocks with their attached barnacles. Collected in this way, they can also be returned alive. Barnacles may be maintained in a saltwater aquarium with relative ease. You can even keep them in a refrigerator if you aerate them periodically with an air pump or by blowing into their water with a straw.

The lab is divided into three sections, which may be performed on successive days, if desired. In the third investigation, a plankton net or fine mesh nylon cloth may be used to collect the larval stages of barnacles. A local plankton shore tow, especially one done during spring, summer or fall, may contain ample larvae.

Circulate through the class as the investigations are being performed. Upon completion of the investigations, plan to provide time for a discussion of the results and techniques, as well as to provide answers to the questions.

Key Words

adaptation - hereditary characteristic of an organism in a population that improves its chances for survival

calcareous - of, containing, or like calcium carbonate

cirri - slender appendages serving as feet

Crustacea - group of arthropod animals (class) possessing a hard shell and including lobsters, crabs, and barnacles

cyprid stage - developmental stage of barnacles characterized by six legs, large antennae, and cement glands

hermaphroditic - characterized by the presence of the reproductive organs of both sexes

nauplius stage - developmental stage of barnacles beginning at about 10 days after fertilization during which the larvae are free swimming; precursor to cyprid stage

substrate - the base on which a sessile (nonmotile) organism lives or grows

taxonomists - scientists who describe, identify, name, and classify organisms

zooplankton - animal plankton

Extensions

1. If time permits, the investigations of the effect of environmental influences on barnacles may be expanded. To observe the role of the cirri in securing oxygen, you may substitute boiled sea water which has less dissolved oxygen in the water. (It is generally observed that the barnacles will increase their beats per minute when placed in water with less oxygen unless that water has no oxygen. Then they will stop moving.)

2. Substitute distilled water and salt solutions of different concentrations for the warm water to show the effect of changes in salinity on metabolism. (It is usually observed that lowering the salinity increases the rate of beating). "Barnacle Beats" in Unit VI: People and the Sea - Estuaries describes in detail how to test the effects of salinity changes on barnacles. The possibilities for experimentation are many.

Answer Key

Part 1

1. Answers will vary. Accept students' hypotheses about what the barnacles are doing as they move.
2. Answers will vary. Accept student predictions about how barnacle movements will vary with water temperature.
3. d. The answer will depend on experimental results. In general, barnacles are more active in warm water. They will slow and stop in water above 25° or 30°C.

Analysis and Interpretation

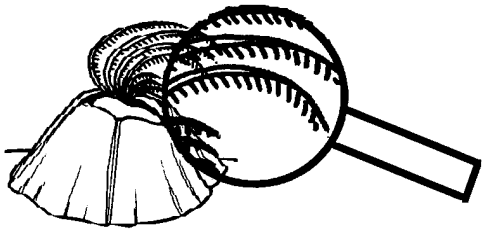
2., 3. Experimental results will vary.

4. Accept student ideas. You may want to share with students that cold water tends to hold more oxygen than warm water. Barnacles may move more in warm water because they are working harder to get oxygen. In addition, barnacles warm as the temperature of their environment warms, increasing their metabolism and speeding up their activity.

Part 2

3. The opening of an acorn barnacle is covered by two pairs, or four, shell plates.

4.



6. Student descriptions of changes in barnacle movements will vary. The barnacles may speed up or slow down. They may extend more or less completely. They may wave their cirri from side to side instead of opening and closing.
8. Answer depends on experimental results. In general, barnacles either continue to extend and retract their cirri but at a faster rate when food is present in order to catch more food, or they hold their cirri open for a long time allowing food to accumulate. This latter behavior will result in lower cirri counts.
9. Student responses will vary. See explanations for cirri movements in answer #8 above.
11. Answers will depend on what students observe. Cirri usually create a definite water current.

Analysis and Interpretation

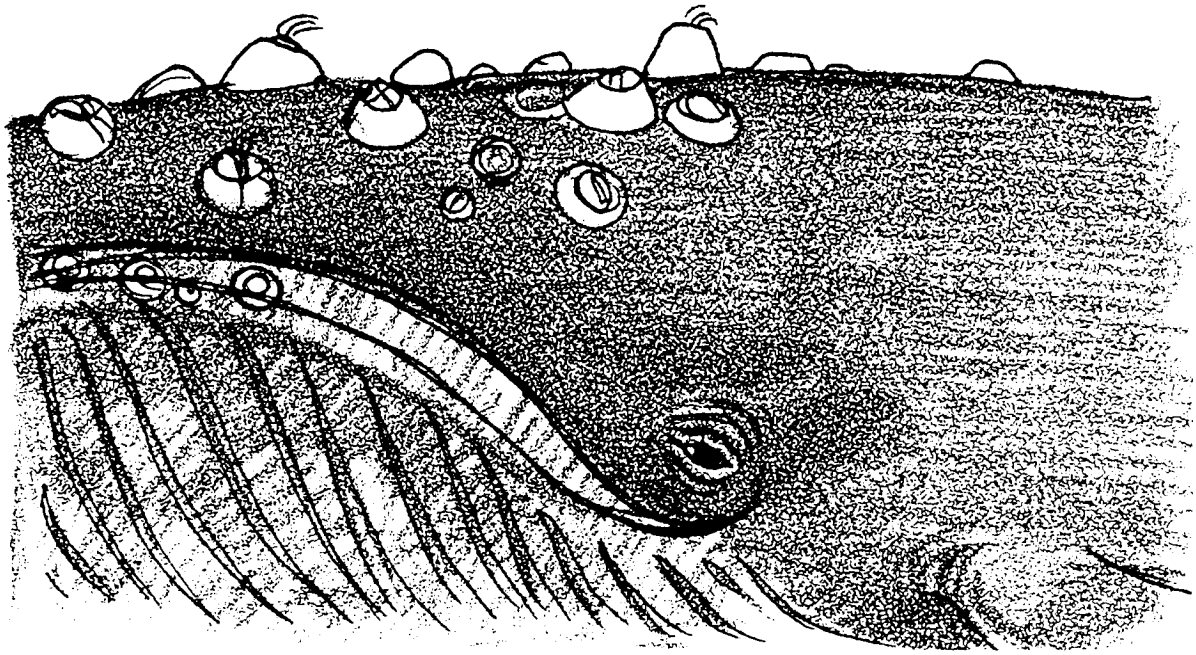
1. A receding tide or the threat of a predator would cause a barnacle to close its shell plates.
2. Answers will vary depending on the behaviors students observed.
3. Barnacles feed by setting up a current with their cirri that brings plankton to them. The cirri then trap the plankton and pull it into the barnacle shell to the barnacle's mouth.

Part 3

Analysis and Interpretation

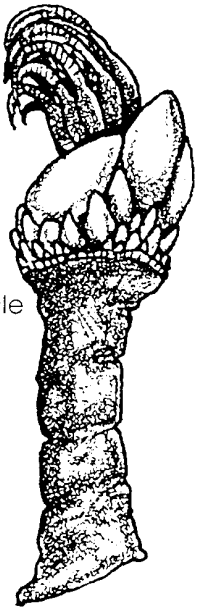
1. The distribution of barnacles is accomplished during the larval stages. The free-floating larvae effectively spread the barnacle population.
2. There are several possible advantages to the crowding seen in adult barnacles. The crowding may serve to trap water and reduce the effects of drying for intertidal species. Crowding facilitates reproduction. Dense aggregations also increase the likelihood of cross-fertilization. It is also possible that the combined beating of numerous cirri may serve to create more substantial currents and move more food and oxygen past the barnacles. Your students will probably have other hypotheses.
3. The most obvious adaptation that helps prevent drying is the moveable shell plates, which may be tightly closed. In addition, the impervious shell also resists drying. The barnacle also traps a small amount of water inside when it closes, thereby reducing the effect of any drying by providing additional moisture. Many of the structures and behaviors observed in studying the barnacle relate to protection from desiccation.

Barnacles: Still Hanging On



If you have been to a rocky or cobbly saltwater beach, you've probably seen or even stepped on a barnacle. These small, white shelled animals are abundant anywhere the salt water is cool and there are solid surfaces to which they can attach. Some species even attach to the backs of whales.

Rock barnacle
Balanus



Adult goose barnacle
Lepas

Barnacles are one of the few rocky shore animals that can live far above the low tide line. Some species live on rocks so far up the beach that they are submerged for only a short time at the highest tides. How can this tough, little animal endure so much time out of the water? How can they survive exposure to very cold temperatures on cold winter nights and very warm temperatures on hot summer days? How can they endure freshwater rainfall and then the influx of salty water at high tide? Who **is** inside that white shell?

Part 1: Observing Barnacles and Investigating the Effect of Temperature on Cirri Movement

Materials

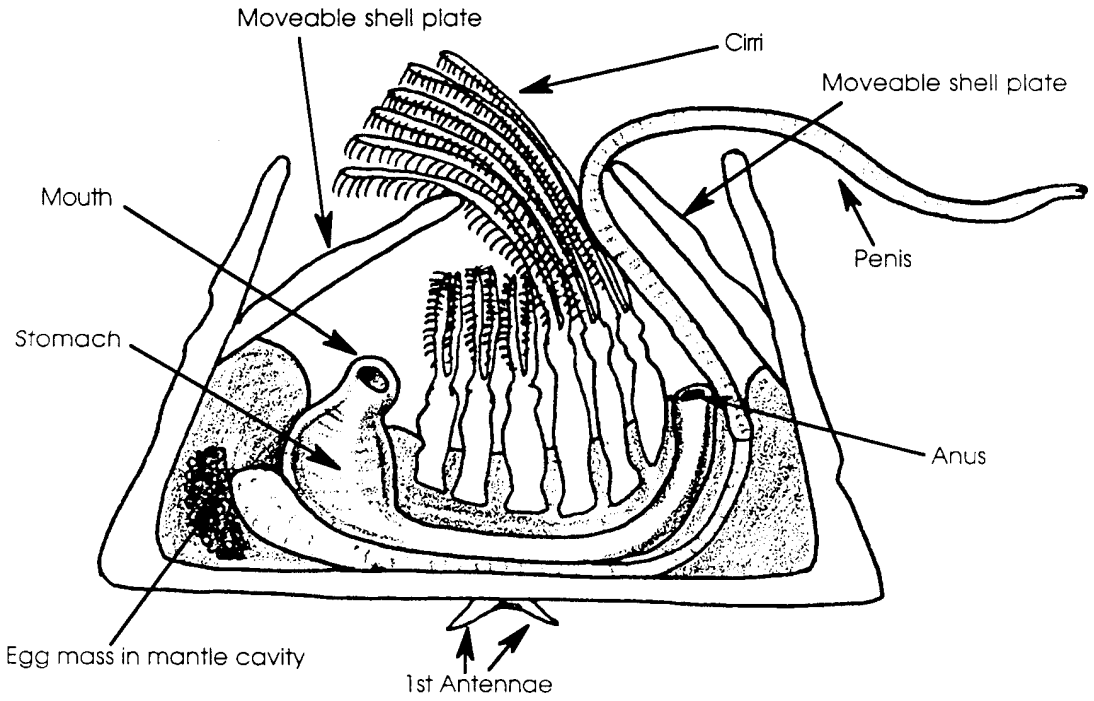
- live barnacles
- finger bowls
- thermometers
- watch or timer with second hand
- cool salt water (5-10° C or so) or ice in dishes to form an ice bath
- warm salt water (15-20° C or so)

Procedure:

1. Place several living adult barnacles in a finger bowl of cool salt water. Watch the barnacles for a few minutes. Find a barnacle that is opening its shell and moving. Sketch what you see below:

What do you think the barnacle is doing as it moves?

The barnacle is actually a shrimp-like creature living on its back inside a shell. The appendages you see moving are called cirri. The barnacle can absorb oxygen through its cirri. The cirri also form a net that the barnacle uses to capture plankton and bring it into the shell to the barnacle's mouth.



Acorn Barnacle
(part of shell removed to show animal in retracted position)

2. Do you think the barnacle will be more active in cold salt water or warm salt water? Explain your reasoning.

3. Test your prediction.
   a. Make sure your barnacles are in cool salt water, between 5° C and 10° C. Either replenish your dish with cool water or rest your bowl in a larger bowl of ice. Do not let the ice get into the barnacle water because it will melt and reduce the salinity of the salt water.

b. After the barnacles have sat in the cool water for five minutes, record the temperature of the salt water on the table below.

c. Find a barnacle that is moving. Count the number of times it beats its cirri in one minute. Repeat this two more times and record your counts on the table below.

d. Replace the cool salt water with salt water which is about lO° C warmer than the cool water in the finger bowl. Let your barnacles rest in this water for five minutes. Record the temperature of the water on your data table.

e. Do the barnacles appear to be more or less active in the warm water?

f. Find a barnacle that is moving and count the number of cirri beats in one minute. Repeat two more times and record your data.

Barnacle Data Table - Part 1

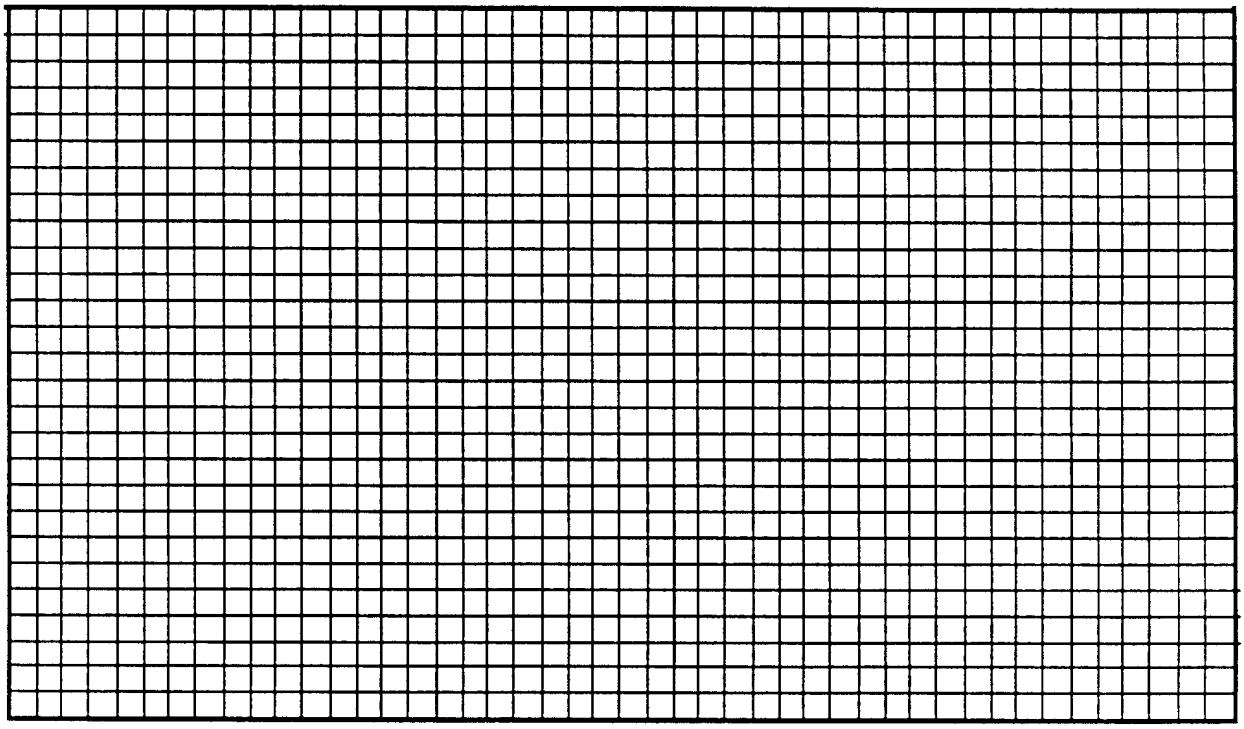
Temperature of cool water	Trial	Cirri beats per minute
_____	1	_____
_____	2	_____
_____	3	_____

Temperature of warm water	Trial	Cirri beats per minute
_____	1	_____
_____	2	_____
_____	3	_____

4. Return the barnacles to the cool saltwater aquarium.

Analysis and Interpretation - Part 1

1. Use the following grid to graph your results. Plot number of beats per minute



on the vertical axis and temperature on the horizontal axis.

2. At which temperature did the cirri beat most rapidly?

3. Observe your graph and the graphs of other students in the class. What is the apparent relationship between water temperature and the action of the cirri?

4. Barnacles are complex animals. There may be many explanations for their behavior. Why do you think they are more active in one temperature than in another?

When the tide goes out, barnacles hold some seawater in their shell, close the plates on top and remain fairly inactive until the tide comes back in. When the water returns, however, they open and move, expelling wastes, acquiring oxygen and sweeping the water for food. The next part of "Barnacles" gives you a chance to feed barnacles and see how they respond.

Part 2: Investigating Barnacle Feeding

Materials

- live barnacles
- finger bowls
- salt water
- dissecting microscopes
- live brine shrimp (*Artemia sp.*), fine fish food, or plankton sample to feed adult barnacles
- glass stirring rod or eye dropper
- vegetable dye (food coloring)

Procedure:

1. Place several living adult barnacles in a finger bowl of salt water.

2. Center the finger bowl on the stage of a dissecting microscope and do not disturb until the barnacles become active.

3. How many moveable plates do you see covering the opening?

4. Draw a close up view of the cirri, showing any small structures you see that might help them trap food.

Cirri movement actually occurs in two steps. First, there is a slow initial step in which the moveable shell plates open and the cirri protrude and unroll. Then there is a rapid second step when the cirri are projected forward as water is sieved through the filtering hairs on the limbs and withdrawn into the body.

5. Find a barnacle that is moving and count the number of cirri beats per minute in this bowl of sea water. Repeat two more times. Record your data in the table below.

6. Place a small amount of food on the end of a glass stirring rod or in an eye dropper and offer it to the barnacle. Describe how the barnacle responds to the addition of food. In what ways are their movements different in water with food?

7. After the food has been in the dish for a few minutes, count the cirri beats per minute three times and record your findings on the table below.

Barnacles Data Table - Part 2

	Trial	Cirri beats per minute
Seawater without food	1	_____
	2	_____
	3	_____
Seawater with food	1	_____
	2	_____
	3	_____

8. In general, did the barnacles move more or less often in the water with food?

9. Why do you think the pace of the barnacle cirri movements changes in water with food?

If it is difficult to see the movement of food into the barnacle, use dye to try tracing the currents the cirri create.

10. Use the eye dropper to gently place a drop of vegetable dye near the portion of the barnacle containing the attached ends of the cirri. In the space below, show direction of the water current created by the cirri.

11. How effective are the cirri in moving water past the barnacle?

12. Return the barnacles to the saltwater aquarium.

Analysis and Interpretation - Part 2

1. In nature, what factors might cause the barnacle to close its moveable shell plates?

2. Did all of the barnacles observed behave in the same way when food was added? If not, explain how the barnacles' behavior differed.

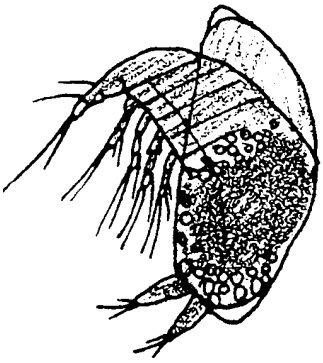
3. How might the water currents caused by the moving cirri help the barnacle to obtain food?

Part 3: Barnacle Life Cycle and Reproduction

Barnacles have to survive periods of exposure during low tide. You have examined ways they capture food and oxygen when the tide does come in. To survive as a species, barnacles also must reproduce. Barnacles reproduce sexually. But how do they do this when they live in small shells attached to rocks or pilings?

Nauplius of barnacle

Barnacles are hermaphroditic, each individual containing both female and male reproductive organs. Each barnacle has a penis to pass sperm to neighboring barnacles to fertilize their eggs. The fertilized eggs are retained within the barnacle and hatch within about ten days. The young develop in the mantle cavity until they reach the free-swimming nauplius stage. At this stage, the nauplius larva escapes and becomes a free living member of the zooplankton.



Cyprid larva of barnacle

The six-legged nauplius molts each three to five days as the animal grows and develops. The mouth and head parts are reduced and the larva develops a bivalve shell resembling a minute clam. The larva now enters the cyprid stage. The cyprid does not feed at this stage of its life cycle. The cyprid larva has six pairs of legs and large antennae. It develops cement glands in the antennae. It crawls about the substrate, testing for an appropriate spot to settle.

The cyprid larva settles to the bottom and attaches itself to a suitable substrate (surface) where it metamorphoses (changes) into an adult. The six pairs of limbs point upward and the mantle secretes calcareous (made of calcium carbonate, like seashells) plates. For the rest of the barnacle's one to seven year life, the plates grow taller and broader at the base to make room for the animal growing inside.

The following activity gives you a chance to observe larval barnacles.

Materials:

- live barnacles
- finger bowls or petri dishes
- fine mesh nylon cloth or plankton net
- dissecting and compound microscopes

Procedure:

1. Obtain living barnacles.

2. Strain the water in which the barnacles were collected or the water in which they were maintained through a fine mesh nylon cloth.

3. Rinse the cloth into salt water in a petri dish or finger bowl.

4. Observe the water under high power of the dissecting microscope and take samples for observation under the compound microscope.

5. In the space below, sketch the larvae you observe:

   a. How many pairs of appendages (legs) do the barnacle larvae you observe have:

   b. What stage(s), nauplius or cyprid, of development have you observed and sketched above?

   c. Label your sketches with the appropriate life cycle stage name(s).

6. Return the water sample to the saltwater aquarium.

Analysis and Interpretation:

1. Adult barnacles are permanently attached to the substrate. How, then, does the population of barnacles get distributed?

2. Adult barnacles often are found closely crowded on pilings and other submerged objects. What advantage might adult barnacles derive from being crowded together?

3. Some barnacles are found living in the intertidal zone where they are exposed to drying and wetting twice every 24 hours. What adaptation helps prevent barnacles from drying out?