# Lesson 8: Effect of temperature on an oyster's heart rate

**Focus Question:**
How does temperature affect the heart rate of an oyster?

**Objective:**
- Students will be able to design an experiment to test an oyster's metabolic response to temperature change.
- Students will be able to describe the relationship between water temperature and metabolism using heart rate as the indicator.

**SC Science Standards:**
Standard 7-1, 8-1: The student will demonstrate an understanding of technological design and scientific inquiry, including process skills, mathematical thinking, controlled investigative design and analysis, and problem solving.

**Purpose:**
In this lab based activity, students investigate the effect of water temperature on the metabolic rate of a cold blooded invertebrate, the oyster.

**Materials:**
*Teacher Preparation:*
- Download video, **Oyster Heart Beat**, from www.cosee-se.org
- Saltwater either collected from estuary (14-21 ppt) or made with artificial sea salts packages.
- Mix salt to dechlorinated or aged tap water for the correct salinity for oysters (a range of 14-21 parts per thousand or 14-21 grams per liter is best).
- Heat source, such as a hot plate.
- Air pump & filter, if you plan to keep oysters for more than one day.

For Each Student Group:
- Two heat proof glass dishes. One dish must be large enough to hold a smaller dish that contains one oyster
- Thermometer
- Stopwatch
- Dissecting kit (or set of tweezers/forceps, scissors, pipette, teasing needle, etc.)
- Oyster Knife
- Oyster Anatomy Cards. laminated
- Oyster Valve Opening Guide (laminated)
- Waste water container
- Gloves

**Recommendations:**
Buy the freshest, single, unshucked oysters at a grocery store or seafood store. Oysters will last about three days if kept refrigerated. You could put oysters in a salt water aquarium with air pump, but they will not live more than a week.

**Safety Concerns:**
Students must wash their hands after handling oysters.

**Vocabulary:**

**Cold-blooded**: an animal that takes on the temperature of their surroundings. They are warm when their environment is warm and cold when their environment is cold. Cold-blooded animals are more active in warm environments because their muscle activity depends on their metabolism which occurs faster when the animal is hot and slower when it is cold.

**Heart Beat:** the squeezing or contractions of the heart muscles to move blood through the body system. Oysters have two-chambered heart and an open circulatory system -- heart muscle pushes the blood from the gills where oxygen is absorbed.

**Heart Rate:** the number of heartbeats per unit of time - typically expressed as beats per minute (bpm). In the oyster, one can see one chamber contracting and other chamber expanding.

**Invertebrate:** an animal without an internal skeleton, such as annelids, echinoderms, mollusks and arthropods. Of the million plus animal species in the world, more than 98% are invertebrates.

**Metabolism:** the chemical reactions that happen in living organisms to maintain life

**Pericardial cavity:** a fluid filled space that contains the heart. The **pericardium** is the thin tissue that covers the heart.

**Warm blooded:** Warm-blooded creatures, like mammals and birds, try to keep the inside of their bodies at a constant temperature. They do this by generating their own heat when they are in a cooler environment, and by cooling themselves when they are in a hotter environment. Warm-blooded animals convert the food that they eat into energy to regulate body temperature when it is cold outside.

**Engaging Students:**

**A. Use a KWL Chart to organize the students' ideas.**

"K" What you know?

Brainstorm with students about what a heart does. See if they can determine their own heart rate (count the pulse on the wrist or neck for 15 seconds and multiply by 4). Discuss what would make their heart rate increase (exercise, heat). Record their "resting heart rate" on the board. Does everyone have the same heart rate? You might ask them to run outside or in gym and take their heart rate again. Ask them about invertebrates and if they have a heart. Would it be the same as ours? Determine the difference between a warm blooded animal, such as human and cold blooded animal, such as an oyster. Please review the vocabulary terms. Write in "K" Column.

"W" What you want to know? Record any questions that students have about heart rate and cold blooded animals.

"L" What have you learned? Complete this column at end of lesson.

**B. Student Challenge: Investigating an oyster's heart rate**

Design an experiment that will investigate if an oyster's heart rate changes with temperature changes.

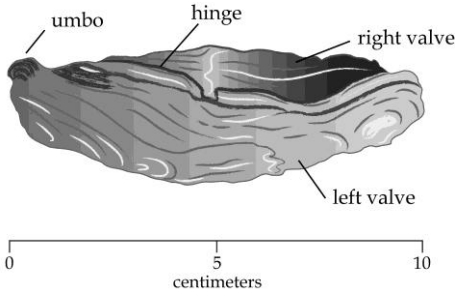
1. Distribute the Oyster Anatomy Cards to students. Review the oyster's anatomy. Refer to the heart's position and the thick adductor muscles which keep the valves tightly closed.
2. Show the video clip of the oyster's heart rate. First, apply the oyster anatomy lesson. Identify the 2-chambered heart and watch the white bulb squeeze from the top to the bottom. Practice counting one beat as the time it takes for the bulb to move from down and then expand again at the top.

**Method:**

1. Experiment Set Up: (For each student group)

a. Distribute materials. The large glass bowl will contain tap water and a small glass bowl or petri disk sitting on a plastic or metal stand within the larger bowl.

b. Each student group will either open one oyster themselves or have a teacher do it for them. See Appendix 3 for directions.




c. Gently place the opened half of the oyster in the small dish and slightly cover the oyster with seawater.

d. Compare the freshly opened oyster with the oyster anatomy card (Appendix 1 and Appendix 2). Try to locate the following parts of an oyster: gills, visceral mass (digestive system), adductor muscle, and pericardial cavity with heart. The oyster should now be "warming" to room temperature from its previous temperature in the cooler.

2. With a dissection needle and scissors, very carefully lift and tear or cut the pericardium tissue to reveal the heart in the pericardial cavity. (Note: this is delicate operation and you may need a second attempt with a different oyster).

3 . First Investigation: The oyster's *heartbeat rate at room temperature Get the facts!*

a. Measure and record the temperature of the water in which the oyster is covered.

b. Watch the heart slowly contract and squeeze one half of the muscle and then the next half; this is one cycle or one heart beat (this may take a minute or more). Count the number of cycles that occur in a 5- minute period. This will give you the "resting heart beat rate."

d. Record data in the Data Table.

4. Second Investigation: *The oyster's heartbeat rate at warmer temperatures.*

a. Place the dishes with water only and the one with seawater and the oyster on the hot plate.

b. Slowly turn up the temperature on the hot plate. The oyster should not be in direct contact with the hot plate.

c. Take the water temperature while continuing to count the heart beats at 3 minute intervals and record the temperature and heart beat rate.

d. Record data in the Data Table.

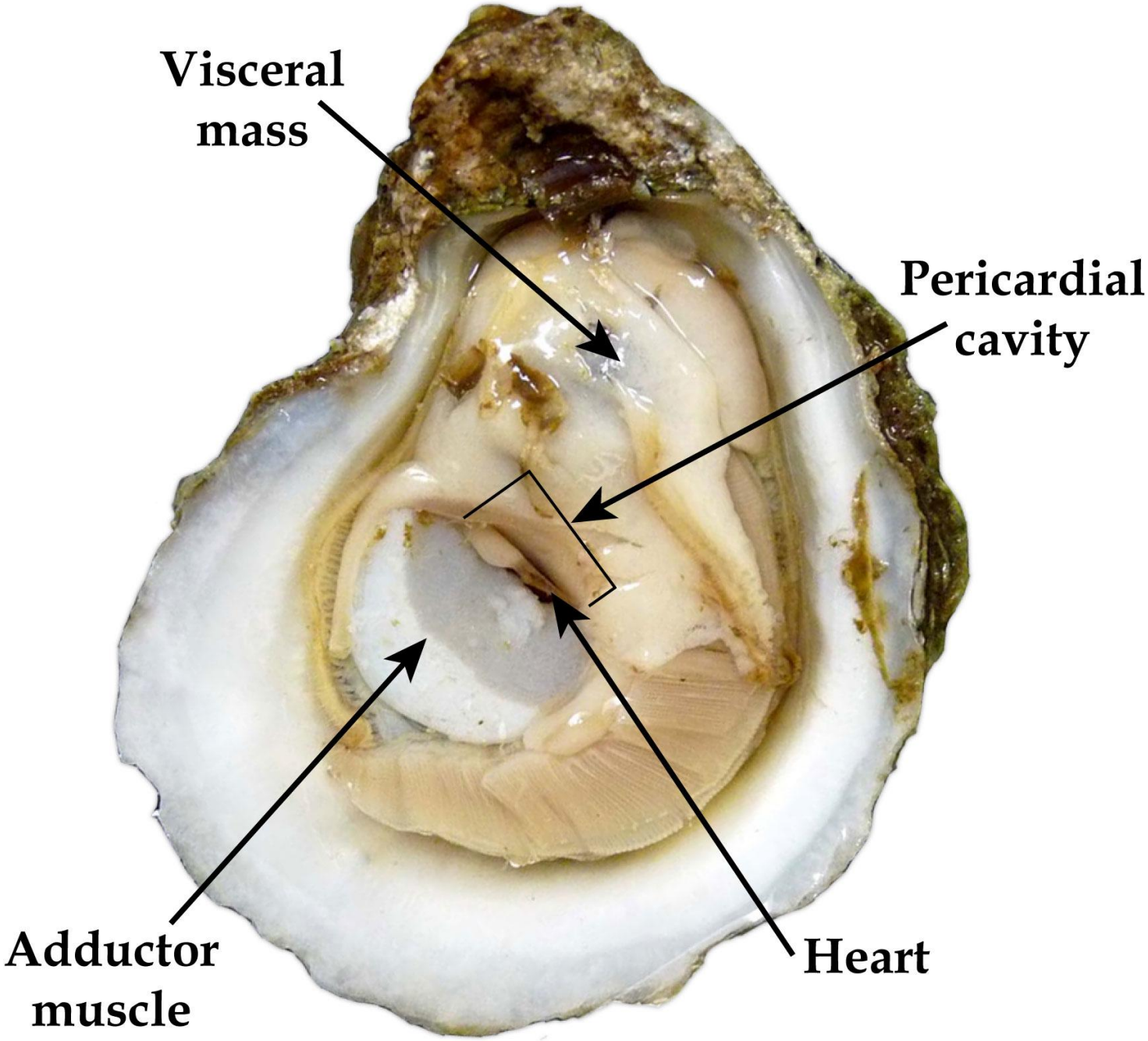
NOTE: Your experiment should run about 12 t0 20 minutes or less. (Caution: If you warm the warm in the large dish too much or too quickly--above 35 degree C or 95 degrees F, the oyster will die.)

The goal is to simply record any change of heart beat rate with temperature, not to get a linear graph.

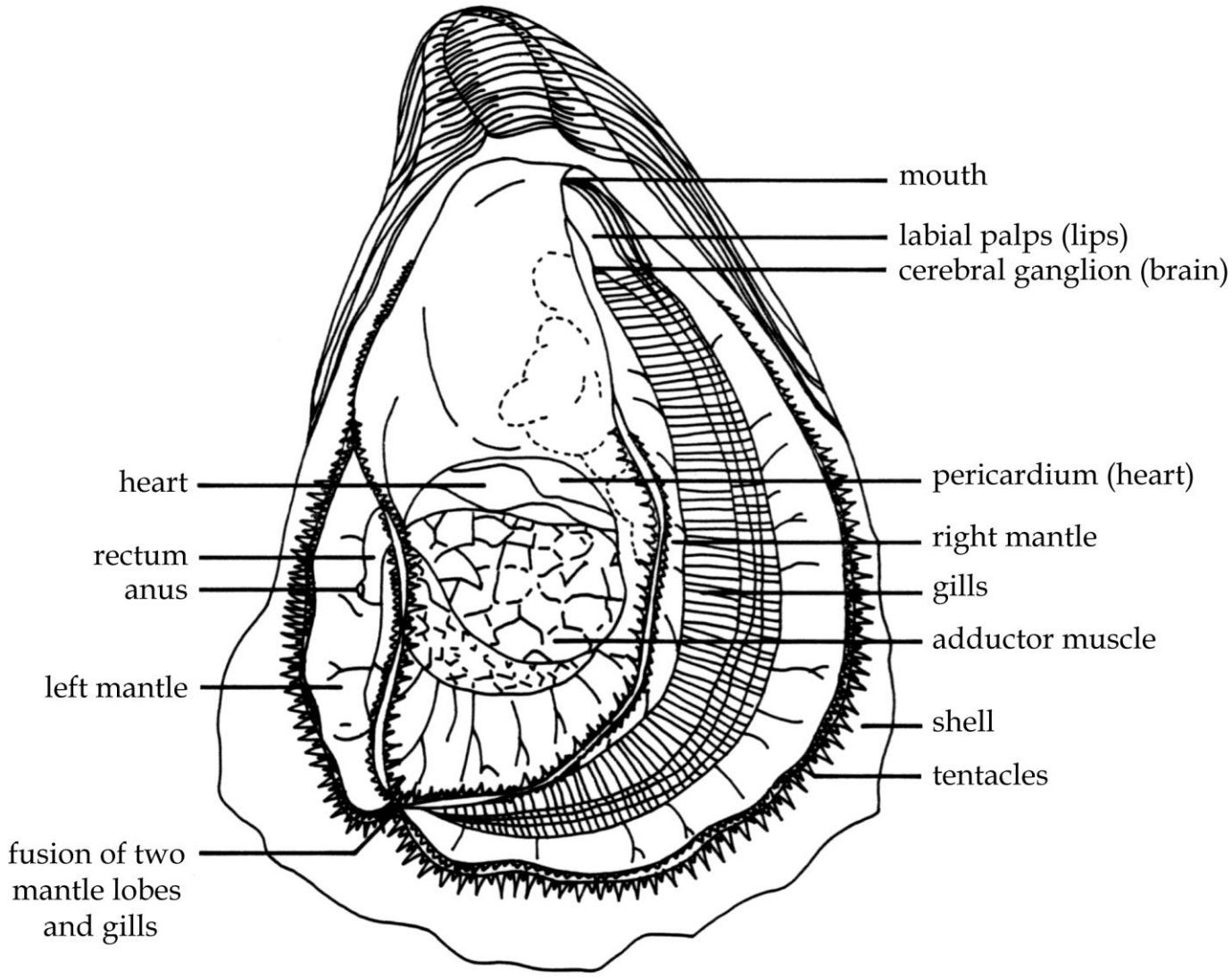
Since each oyster is different and may have been damaged while shucked, students may wish to replicate this experiment with a second or third oyster. Then they can average the heart rate at similar water temperatures.

**Appendix 1 Oyster Anatomy Card**

Visceral Mass is the digestive area, pericardial cavity contains the heart, adductor muscle attaches to both valves and keeps the oyster shut.



**Appendix 2: Additional Oyster Anatomy**



**Appendix 3: Oyster Valve Opening Guide:**

**DO NOT ATTEMPT THIS BY YOURSELF. You must wear protective gloves.**

| | |
|---|---|
| **Step 1:** With a glove on, hold an oyster firmly in your hand. Place the left valve of the oyster, down towards the table—this is the deeper side. |  |
| **Step 2:** Insert the knife into the oyster's hinge (where the two valves meet). |  |
| **Step 3:** Twist the knife until the hinge pops. |  |
| **Step 4:** Carefully insert the knife in the region of the upper edge of the right (flat) valve. Feel for the adductor muscle that connects the two values and cut it from the upper shell. Now you remove this half of the shell. Leave the animal in the deeper left valve. |    |
| **Step 5:** Find the white colored, round, adductor muscle that you just cut. |  |
| **Step 6: Find the heart.** The heart is located in the pericardial cavity close to the adductor muscle. Carefully remove the pericardium tissue to reveal the two-chambered heart. |  |

**Appendix 4. Student Lab Sheet (Teacher's Copy)**

Student Challenge:
In this investigation, your challenge is to identify the effects of temperature on the oyster. You will do this by observing the heart rate (beats per minute) of oysters in a range of temperatures.

Draw & Label your experiment set up:

Research Question:

*Sample Question: How does water temperature affect an oyster's heart rate?"*

"How does _____ affect _____?"

Methods :
*Sample answer:*
*1. After opening oysters carefully with an oyster knife, put into the petri dish with seawater. Allow recently cooled oyster (since it was in the refrigerator or cooler) to return to Room Temperature.*
*2. While the oyster is acclimatizing to room temperature, observe the oyster's anatomy, making sure that you find the pericardial cavity. Sketch and label your own anatomy of the oyster.*
*3. After about 5-15 minutes, the oyster's heart should be beating regularly (very slowly), if the valves were separated without damaging the oyster's organs.*
*4. Record temperatures of the water holding the oysters at the start.*
*5. Using a timer, count the number of beats over a five minute interval. One beat is measured by the time it takes for one cycle of the "bulb" of the heart to move from one side to the other and, then, return to its original position.*
*6. Collect data in data table.*
*7. Repeat Steps 4-6 as you slowly warm water from room temperature, but at the 3 minute intervals. Do not test with water hotter than 35°C. This will kill the oyster*

**Results:**

Data Table 1: Room Temperature: *Sample answers*

| Time | Water Temperature | Heart Rate (Total # of Beats / minute) in the 5 minute interval |
|---|---|---|
| 0 min(Start) | *68 degrees F* | |
| 1 min | *68 degrees F* | |
| 2 min | *68 degrees F* | |
| 3 min | *68 degrees F* | |
| 4 min | *68 degrees F* | |
| 5 min (end) | *68 degrees F* | **# of Beats /5= 2 hbp* |

Data Table 2: Warming Temperature: *Sample answers*

| Time | Water Temperature | Heart Rate (Total # of Beats / minute) in the 3 minute interval |
|---|---|---|
| 0 min(Start) | *68 degrees F* | |
| 1 min | *68 degrees F* | |
| 2 min | *70 degrees F* | |
| 3 min | *70 degrees F* | **# of Beats/3= 1 hbp* |
| 4 min | *70 degrees F* | |
| 5 min | *71 degrees F* | |
| 6 min | *71 Degrees F* | **# of Beats/3=1 hpb* |
| 7 min | *71 degrees F* | |
| 8 min | *73 degrees F* | |
| 9 min | *73 degrees F* | **# of Beats/3= 2 hpb* |
| 10 min | *75 degrees F* | |
| 11 min (continue table as needed) | *75 degrees F* | |

c. What happened to the heart rate as the water warmed? What is your evidence? *The oyster's heartbeat rate sped up.*

d. Summarize what you observed:
*Answers will vary*

**Conclusion:**

a. What is the relationship between water temperature and heart rate?
*As water temperature increases, the oyster's heartbeat rate speeds up.*

b. Based on this experiment, what is the relationship between water temperature and a cold-blooded animal's metabolism?
*Water temperature on aquatic organisms will affect their heartbeat rate which can increase metabolic activity.*

**Student Reflection:**
Can you relate what an oyster's heartbeat rate does in relation to seasonal temperatures?
*Winter heartbeat rates are slower due to cold water and summer oyster heartbeat rates are faster due to hotter water.*

**Focus Question: How does temperature affect the heart rate of an oyster?**

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"How does _____ affect _____?"

Methods :

**Results:**

Data Table 1: Room Temperature: *Sample answers*

| Time | Water Temperature | Heart Rate (Total # of Beats / minute) in the 5 minute interval |
|---|---|---|
| 0 min(Start) | | |
| 1 min | | |
| 2 min | | |
| 3 min | | |
| 4 min | | |
| 5 min (end) | | # of Beats /5 min= hbp |

Data Table 2: Warming Temperature: *Sample answers*

| Time | Water Temperature | Heart Rate (Total # of Beats / minute) in the 3 minute interval |
|---|---|---|
| 0 min(Start) | | |
| 1 min | | |
| 2 min | | |
| 3 min | | # of Beats/3 min= hbp |
| 4 min | | |
| 5 min | | |
| 6 min | | # of Beats/3 min= hpb |
| 7 min | | |
| 8 min | | |
| 9 min | | # of Beats/3 min= hpb |
| 10 min | | |
| 11 min (continue table as needed) | | |

c. What happened to the heart rate as the water warmed? What is your evidence?

d. Summarize what you observed:

**Conclusion:**

a. What is the relationship between water temperature and heart rate?

b. Based on this experiment, what is the relationship between water temperature and a cold-blooded animal's metabolism?

**Student Reflection:**
Can you relate what an oyster's heartbeat rate does in relation to seasonal temperatures?

**Focus Question: How does temperature affect the heart rate of an oyster?**