



# Respiration Rate Changes in Goldfish as a Function of External Temperature

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## Appropriate citation:

Beck, L. Respiration Rate Changes in Goldfish as a Function of External Temperature (APS Archive of Teaching Resources Item # 1801). [Online]. Bethesda, MD: American Physiological Society, 1997. <http://www.apsarchive.org/resource.cfm?submissionID=1801>.

## Editor's notes:

The APS encourages teachers to give students a copy of the "ABC" (Appropriate, Beneficial, Caring) rules for use of animals in the classroom, to discuss the rules, and to ask students to sign the "ABC" rules contract (see References). Also, teachers should have a plan for short term care of the animals (with supporting references for appropriate care guidelines) and for disposal or long-term care of all classroom organisms.

Teachers should carefully review any stimulus or environmental change for an animal being used in experiments or observations before students are allowed to use that stimulus. This is especially important if the stimulus could cause pain or distress to the organism. Teachers may be able to identify a less stressful stimulus for the students to use in their experiment.

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**Purpose:**

To observe and record the different ways in which the respiration rate in fish changes as a function of external temperature.

**Grade Level:** Middle School

**Objectives:**

Students will be able to:

- Directly observe the physiological changes that occur as a result of changes in water temperature.
- Study the physiological processes and record measurements in the same way that physiologists do.
- use prior knowledge to develop a hypothesis about physiological changes resulting from environmental temperature changes;
- Design and carry out an experiment to test their hypotheses.
- Gain an understanding of the importance of using animals in physiological research.

**Materials:**

- goldfish
- fish tank or large storage vessel
- water at room temperature
- fish nets
- lab handouts
- scrap paper

**Other Materials:**

These items should be sequestered and only made available *after* students have outlined their experimental procedures and have received permission to proceed. These materials are based on a class of 24 students working in six groups of four students.

- 6 thermometers
- 6 hot plates
- 24 goggles
- one large source of crushed ice
- one cooler
- beakers of assorted sizes (400 ml, 600 ml, 1000 ml—about one dozen of each size.)
- 6 calculators

**Preparation:**

This lab is an excellent follow-up lab to the engage activity “What Types of Bodily Changes Can You Observe in Situations of Varying Environmental Temperatures.” It is an inquiry activity designed for studying human respiration in high school biology. Plan on devoting two to four, 45-minute lab periods for this investigation.

Goldfish are relatively inexpensive and may be purchased at a local pet shop. If an aquarium with filter and aerator is available to house the fish, plan on buying two to three fish per group (for a class of 24 students you should purchase approximately 24 fish). If no aquarium is

available, you may use a clear plastic bucket. Be sure you fill the bucket with tap water 24 hours prior to its use, allowing it to “rest.” Also, plan on getting four to five fish per group as the fatality rate during the night may be higher (for a class of 24 students you should buy 12-18 goldfish). Allow time before the lab to remove any fish that may have expired during the night and be sure to check with the laws in your particular state regarding use of vertebrates in the lab.

A discussion of the importance of using live animals in physiological research is appropriate here along with a discussion of the importance of integrity in working with animals. On the day before the activity, review the proper way of handling goldfish with students stressing that students should be careful in how they handle the fish to avoid injuring them.

Also, ask students to think about temperature ranges suitable for the study. The temperature changes for the fish (at maximum) should not exceed 10° in either direction since this could result in physiological shock to the goldfish. The temperature should not exceed 35° Centigrade at any time. Guide students as they think of ways to minimize temperature shock to the fish, e.g., studying only small temperature changes or immersing fish in a small beaker, which is then immersed in a larger beaker with a pronounced temperature difference.

### **Procedure:**

Divide students into groups of four to insure student equity through random separation; you may wish to use a deck of cards for this purpose. Each team will be composed of all four suits of a particular number (e.g., Group 1 would include students with the three of hearts, spades, clubs, and diamonds). Each suit of any group number will be assigned a different job (e.g., recorders = hearts; material gatherers = spades, technicians = clubs, fish supervisor = diamonds.) Explain to students that they will have an opportunity to directly observe physiological changes (breathing rate/respiration rate) in response to environmental temperature changes. Each team will pose a hypothesis regarding how temperature might affect respiration rate in goldfish. Each team will need to provide the following information on the laboratory worksheet: hypothesis, materials, procedure, control, results and conclusion. Additionally, each group at the outset will need to clearly explain how the respiration rate will be observed and measured.

Groups will have to review their experimental design with a teacher before beginning their project, and teacher approval is required to continue the investigation for both experimental design and data collection (see student worksheet). Each group will complete their experiment, record their data, write conclusions, and note any new questions that the experimental results generate among the group and describe any changes in the experimental design that they would recommend.

### **Safety:**

- Students should wear aprons and safety goggles for the entire lab.
- Students should exercise great caution when using a hot plate and working with hot water.
- Students should wear gloves or wash hands thoroughly after handling fish or aquarium water.

### Questions to Ask:

- What happened to the fish's respiration rate as the temperature changed?
- What is the connection between metabolism and respiration, i.e., why should temperature have anything to do with respiration rate? At what temperature did students observe the highest metabolic rate in the fish? The lowest?
- At what temperatures did students observe the fish needing the most food and oxygen?
- What could students predict might happen to the activity of fish in cold climates during the winter months?
- How can fish survive in a frozen pond or river during the winter?

### Where to Go From Here:

Students could follow-up this lab with an exploration of how environmental temperatures affect blood flow rate in goldfish. For this activity, students could directly observe flow rate changes in the capillaries of goldfish tails using compound microscopes. Alternatively, small red worms could be adapted for a blood flow lab in observing how environmental temperatures affect respiratory and circulatory systems.

### References:

1. American Physiological Society (APS). "ABC" rules for use of animals in the classroom. [Online]. Bethesda, MD: American Physiological Society, 2007. <http://apsarchive.org/resource.cfm?submissionID=4288>.
2. *Biology: The Study of Life*. (1993). Englewood Cliffs, NJ: Prentice Hall.
3. Smith, Stan. *Classroom Animals: Beyond Observation. A Practical Guide to Real Science with Live Animals*. (Write to S. Smith at 805 Laurel Drive, Warrenburg, MO 64093).
4. The British Physiological Society. *Physiology: An Inside View* (videotape). Bethesda, MD: The American Physiological Society.
5. The American Physiological Society (APS). (1997). *Questions People Ask About Animals in Research* (brochure). Bethesda, MD: APS.
6. Van Cleave, Janice. (1995). *The Human Body for Every Kid*. New York: John Wiley & Sons, Inc.

### Suggestions for Assessment:

Each group will present their work for five minutes to the entire class. Students will also graph both by hand and by computer their data. As a follow up assessment, students may be assigned "mini-reports" on applications of their data. Such applications may be in the apparel industry, construction industry, pharmaceutical industry, OSHA, etc. This latter assessment is ideally suited for interdisciplinary work with the Social Studies Department.

## Respiration Rate Changes in Goldfish as a Function of External Temperature

### Student Activity: Sheet #1

#### **Purpose:**

To observe and record the different ways respiration rate in fish changes as a function of external temperature.

#### **Procedure:**

Your team will design an experiment to observe how temperature affects respiration rate in goldfish. The following information will need to be provided for each group:

- Indicate your group number [the card number you all share] and what job each person on your group performs, e.g., recorder, material gatherer, technician, etc.
- How will you observe and accurately record respiration rate?
- What is your team's hypothesis?
- What materials will your team need?
- Record your procedure being sure to identify your control. Your team will first have to obtain approval for your procedure before proceeding. You should also be sure to record your respiration rate at any given temperature at least three times for accuracy.
- Record your results.
- Graph your data both by hand and by using a computer program.
- State your group's conclusion.
- At the conclusion of the lab, each group will make a five-minute presentation to the entire class regarding your experimental design and results.

#### **Caution:**

- Be careful handling the fish throughout the activity to avoid injuring them
- Temperature changes should not go above or below 10° Celsius from room temperature
- Do not allow the water temperature to exceed 35° Celsius.

## Respiration Rate Changes in Goldfish as a Function of External Temperature

### Student Activity: Group Worksheet

Group # \_\_\_\_\_

Name Group Job

**Answer the following questions on attached sheets of paper. Number each answer with the question number.**

1. How will your group observe and accurately record goldfish respiration rate?
2. State your proposed hypothesis.
3. List the materials needed.
4. Describe your procedure step-by-step (for example, a), b), etc.).
5. What is the control for your experiment?
6. Results: Draw a data table that will be suitable for collecting your group's data being sure to record the temperature three times at any given temperature.
7. Get your teacher's approval to proceed. Approval to proceed \_\_\_\_\_
8. What conclusions can you draw from your findings?
9. List any additional questions about respiration, temperature regulation, or goldfish, in general, which your experiment led you to think about.
10. Describe any changes or improvements you would make in your experimental design.