

**2008  
Winning Lesson Plan  
from Coventry,  
Rhode Island**

*Investigation of the Effects  
of Thermal Pollution on  
Fish Metabolism*

by William Brew  
Coventry High School

Subject: Aquatic Ecology  
Grade Level: 11–12  
Duration: Two 84-Minute  
Class Periods

## Overview and Purpose

Students will design and implement an experiment that will simulate thermal pollution in an aquatic ecosystem. Students will indirectly measure metabolic rate by observing the respiration rate of goldfish as temperature is varied.

Students are presented with two core questions: What is the effect of thermal pollution on fish? and How does fish size (mass) effect the ability to adjust to thermal pollution. Students will be given means and materials to investigate these questions in a laboratory setting. Students will conduct research, assemble a hypothesis and design an authentic experiment to determine the effects of thermal pollution.

## Innovative

The fish respiration lab has an innovative piece in that we are using live animals and subjecting them to changing environmental factors. Students can infer metabolic changes through breathing rates of the fish and measure the impact of such changes on fish of various sizes (mass).

## Unit Description and Goals

This lab activity tie into a unit on lake stratification (layering) due to the temperature / density dynamics of water. The goal of the unit is to investigate how the water column of a lake transitions throughout the year and how living things have adapted to survive environmental influences.

**2008  
Winning Lesson Plan  
from Coventry,  
Rhode Island**

*Investigation of the Effects  
of Thermal Pollution on  
Fish Metabolism*

by William Brew  
Coventry High School

Subject: Aquatic Ecology  
Grade Level: 11–12  
Duration: Two 84-Minute  
Class Periods

## Educational Standards Addressed

- S2 Life Sciences Concepts
  - S2d Interdependence of organisms, such as conservation of matter; cooperation and competition among organisms in ecosystems; and human effects on the environment [Aligns: Thermal pollution caused by human activity]
  - S2f Behavior of organisms, such as nervous system regulation; behavioral responses; [Aligns: Fish physiological response to temperature change]
- S5 Scientific Thinking
  - S5a Frames questions to distinguish cause and effect; and identifies or controls variable in experimental and non-experimental research settings [Aligns: Design an authentic experiment]
  - S5f Works individually and in teams to collect and share information and ideas [Aligns: Lab work performed in pairs]
- S6 Scientific Tools and Technologies
  - S6a Uses technology and tools (such as traditional laboratory equipment, video, and computer aids) to observe and measure objects, organisms, and phenomena, directly, indirectly, and remotely, with appropriate consideration of accuracy and precision [Aligns: Measurement of mass, temperature and breathing rate]
- S7 Scientific Communication
  - S7a Represents data and results in multiple ways, such as numbers, tables, and graphs; drawings, diagrams and selects the most effective way to convey the scientific information [Aligns: Data collection in tables and graphs]
  - S7b Argues from evidence, such as data produced through his or her own experimentation or data produced by others [Aligns: Use data to support/reject hypothesis]
  - S7e Communicates in a form suited to the purpose and the audience, such as by writing instructions [Aligns: written lab report]
- S8 Scientific Investigation
  - S8a Controlled experiment [Aligns: Design an authentic experiment]

**2008  
Winning Lesson Plan  
from Coventry,  
Rhode Island**

*Investigation of the Effects  
of Thermal Pollution on  
Fish Metabolism*

by William Brew  
Coventry High School

Subject: Aquatic Ecology  
Grade Level: 11–12  
Duration: Two 84-Minute  
Class Periods

## Objectives

Upon completion of this activity, students will be able to:

1. Design an experiment to measure the effects of changing water temperature on fish respiration (guided with teacher, with set parameters).
2. Design a second experiment examining the relationship between water temperature and respiration rate of different size (mass) fish.
3. Conduct an experiment demonstrating proper maintenance and care of live animals.
4. Share their findings with a written laboratory report.

## Materials

1. Balance (mass)
2. Beakers
3. Goldfish of differing sizes (mass)
4. Hot plate
5. Thermometers
6. Ice bath
7. Stopwatch

**2008  
Winning Lesson Plan  
from Coventry,  
Rhode Island**

*Investigation of the Effects  
of Thermal Pollution on  
Fish Metabolism*

by William Brew  
Coventry High School

Subject: Aquatic Ecology  
Grade Level: 11–12  
Duration: Two 84-Minute  
Class Periods

## Procedures

### Part 1: (Small Fish)

Students should be familiar with proper care and maintenance of the fish prior to beginning the lab. Students should also know the difference between temperature maintenance in warm- versus cold-blooded organisms. Fish respiration can be clearly seen either by watching a fish's mouth or gill movement. Students will count the number of respirations while placing the fish in beakers using water of varying temperatures. Students need to figure out how to determine the mass of each fish and record before experimenting begins. Students will need to construct their own procedure during this inquiry lab, but work within the parameters listed:

- all fish must stay alive
- respiration rate is recorded in breaths / minute
- each fish must have at least 4 minutes of recovery time in the water
- temperature before data is collected
- water temperatures can range from 5 to 45 degrees C

Note: Data is to be collected and organized in a table.

### Part 2: (Large Fish)

Students repeat the procedure developed in part one with a larger goldfish. Data is to be collected and organized in a second table. Students can determine the oxygen demands of large vs. small fish by the following calculation for data collected at each temperature:

- Respiration rate (breaths/minute)
- Mass of fish (grams)
- The resulting data will be in breaths/minute/gram body weight for each sized fish.

## Fish Respiration Lab Report

Items must appear in the following order.

This sheet must be completed and attached as last page of report or it will not be graded.

2008  
Winning Lesson Plan  
from Coventry,  
Rhode Island

*Investigation of the Effects  
of Thermal Pollution on  
Fish Metabolism*

by William Brew  
Coventry High School

Subject: Aquatic Ecology  
Grade Level: 11-12  
Duration: Two 84-Minute  
Class Periods

Check Box	Item	15	10	5	0	Self Score	If you did not award yourself full credit, BRIEFLY explain why	Score
1	Problem Statement							
	What is the problem we are attempting to solve? Write in the form of a question.	Problem clearly stated. Cannot be answered with a yes or no	Problem statement accurate but, could be answered with a yes or no	Problem statement unclear or inaccurate.	Problem statement missing or not acceptable.			
2	Background Information							
	Define breathing respiration, compare the breathing respiration anatomy of a human and a fish	Definition is accurate and examples are correct and relevant	Definition is included but lacking information. Examples are correct and relevant	Definition is accurate and one example is correct and relevant	Both definition and examples are incorrect or missing			
3	Hypothesis							
	How do you expect the respiration rate to change as water temperature changes? Different sized fish?	Prediction is clearly stated and measurable	Prediction is stated and somewhat relevant to the problem	Prediction inaccurate but somewhat relevant to the problem	Both predictions are missing or not relevant to the problem			
4	Experimental Procedure							
	Materials list, Step by Step (numbered) detailed directions, explain when and where data should be recorded	Materials list complete and accurate. Detailed and easy to follow directions	Materials list missing one or more items. Directions complete but lack detail	Materials list missing three or more items. Directions included but not complete	Materials list missing and directions inaccurate or missing			
5	Data							
	Data Table and computer generated graph	Table and graph included. Outstanding attention to detail.	Table and graph included. Missing one axis label or title information	Table and graph included. Missing two axis labels or title information	Table or graph missing or unacceptable.			
6	Conclusion							
	Restate hypothesis, support/reject your hypothesis, Explain why  USING YOUR DATA X 2	Hypothesis included as first sentence. Clearly states accept or reject hypothesis. Refers to five or more facts from sketches and observations to support conclusion.	Hypothesis included as first sentence. Clearly states accept or reject hypothesis. Refers to three or more facts from sketches and observations to support conclusion.	Hypothesis included as first sentence. States accept or reject hypothesis. Refers to one or more facts from sketches and observations to support conclusion.	Hypothesis included as first sentence. States accept or reject hypothesis. Does not include facts from sketches and observations to support conclusion.			
	Format							
	Typed document, spelling and grammar correct, appropriate margins and limit amount of wasted space, 12 pt., appropriate font, stapled, sections in order, creative cover page with name, date, appropriate illustration, completed rubric as last page	Typed document, spelling and grammar correct, appropriate margins and limit amount of wasted space, 12 pt., appropriate font, stapled, sections in order, creative cover page with name, date, name of lab and an appropriate illustration, completed rubric as last page	MISSING ONE of the following: Typed document, spelling and grammar correct, appropriate margins and limit amount of wasted space, 12 pt., appropriate font, stapled, sections in order, creative cover page with name, date, name of lab and an appropriate illustration, completed rubric as last page	MISSING THREE or MORE of the following: Typed document, spelling and grammar correct, appropriate margins and limit amount of wasted space, 12 pt., appropriate font, stapled, sections in order, creative cover page with name, date, name of lab and an appropriate illustration, completed rubric as last page	MISSING FIVE or MORE of the following: Typed document, spelling and grammar correct, appropriate margins and limit amount of wasted space, 12 pt., appropriate font, stapled, sections in order, creative cover page with name, date, name of lab and an appropriate illustration, completed rubric as last page			

**2008  
Winning Lesson Plan  
from Coventry,  
Rhode Island**

*Investigation of the Effects  
of Thermal Pollution on  
Fish Metabolism*

by William Brew  
Coventry High School

Subject: Aquatic Ecology  
Grade Level: 11–12  
Duration: Two 84-Minute  
Class Periods

## Extensions Beyond the Classroom

Part 2 is a natural continuation of Part 1 in this activity. If a teacher chooses to use Part 1 only of the lab, it can be integrated into either a physiology or adaptation unit. If it is included with an adaptation unit, students can play an active role in setting up the tank and choosing an appropriate mix of fish which can share a common space. If it is used as part of a physiology unit, the principles and parameters for designing an experiment with fish or other live animals (including humans) can be used again pertaining to other body systems. Students may have other questions related to the aquatic environment, such as sources of thermal pollution, effects of climate change, human habitat alterations, fish adaptations for survival.

Adapted From: [The Effects of Water Temperature Change on Goldfish Physiology and Behavior](http://www.the-aps.org/education/k12curric/activities/pdfs/pittis-fish.PDF)  
(<http://www.the-aps.org/education/k12curric/activities/pdfs/pittis-fish.PDF>)