

Dissolved oxygen is a very important factor in water quality. Most aquatic animals and all fish breathe the oxygen dissolved in water. The dissolved oxygen concentration can vary widely in bodies of water, and in doing so it helps determine which animals live where.

Oxygen enters the water in a number of ways, from the surface, from wind and turbulence, and from water plants, but the amount of oxygen which the water can actually hold in solution depends upon water temperature. Cold water can hold much more oxygen in solution than warm water.

Salmon require especially high levels of dissolved oxygen. For this reason, salmon live only in relatively cold water, below 68 degrees F. They are especially vulnerable to oxygen starvation.

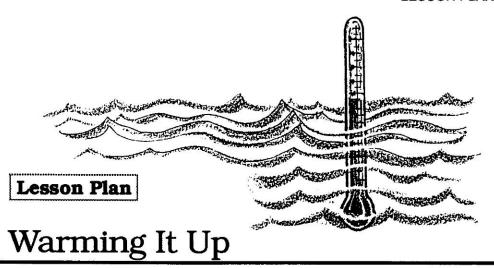
Oxygen starvation can result from high temperatures as illustrated in this activity, or it can be caused by biological oxygen demand. Biological oxygen demand results when organic matter such as sewage or sawdust decays in the water. As organic material decomposes, it combines with oxygen, often robbing dissolved oxygen from the water.

Students will work in groups for this activity. The materials list for this lesson assumes a maximum of six groups, but you can adjust the materials if you prefer a smaller group size.

The students will need goldfish for this activity. Goldfish can easily be kept in a classroom aquarium. They can live at room temperature but do require an aerator and aquarium filter. During the experiment, the fish will be placed in water samples of different temperatures. You and the students should take care that as experimental animals, the fish are treated respectfully and their health and comfort is never threatened.

You will need to prepare the water used for the experiment in advance. If each group works with quantities of about a pint, you will need at least one gallon of each water sample. The first sample is simply room temperature water. Remember to let the water stand out overnight to allow the chlorine to evaporate. The second is water which has been refrigerated overnight. The third sample consists of boiled water which has been allowed to cool to room temperature to be safe for the fish. By covering the water before it is cooled you can prevent oxygen from re-entering the water. First boil the water, then pour it into a plastic gallon jar or two large plastic yogurt containers and close tightly. (A tightly sealed glass jar may break.) In dispensing the water samples to your students, you should take care that the water is poured with a minimum of turbulence to prevent oxygen from re-entering the water.

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Student Objectives:

Students will measure the effect of different water temperatures on the breathing rate of fish. They will determine the relationship between water temperature and the amount of oxygen present in the water.

Materials:

- One copy per student, WARMING IT UP
- 6 goldfish
- · 6 large plastic cups for transferring fish
- 6 small aquarium fish nets
- · 6 wide-mouth quart jars
- 1 gallon room temperature water
- 1 gallon refrigerated water
- · One gallon boiled, then cooled water

(see Teacher Background for preparation directions.)

· 6 stopwatches or clock with second hand

Procedure:

- 1. Explain to your students that water temperature is very important to fish, especially salmon. This is largely because of an important relationship between temperature and the ability of water to hold oxygen. Your students may be unaware that water has oxygen dissolved in it. This can be demonstrated most graphically by allowing a glass of water to stand in a warm room until bubbles form along the sides of the glass.
- 2. Ask your students why oxygen is important to fish. Most should know that fish, like all animals, breathe oxygen and release carbon dioxide. You might also ask your students how fish manage to extract oxygen from the water. Fish and many other aquatic animals use gills, elaborate organs which expose large areas of a porous membrane to moving water so that oxygen and carbon dioxide can be exchanged with surrounding water.
- 3. Explain that they will be doing an experiment using live goldfish to determine for themselves whether more oxygen is present in cold water or in warm water. Groups of 4 or 5 students will work together on the experiment.

LESSON PLAN

- 4. Each group will need:
 - one fish in a large plastic cup
 - · small net to transfer fish
 - · one wide-mouth quart jar
 - · a stopwatch or view of clock with a second hand
 - WARMING IT UP data sheet
- **5.** Have your students fill the quart jar with room temperature water. Then have them place the goldfish in the jar, allowing it a minute to adjust to the jar. They will take turns timing the number of breaths the goldfish takes in a 15-second interval and recording the results of at least six timings on their data sheet.

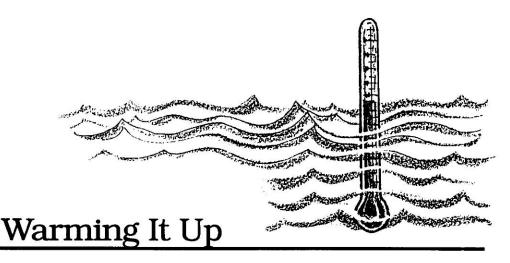
They will then average the six trials for their final figure.

- **6.** Have the students remove the goldfish from the jar, pour out the room-temperature water and then fill the jar with refrigerated water. They can then repeat the experiment with this water. Finally, have them follow this procedure with the boiled water.
- 7. After the fish have been returned to the aquarium, discuss student observations. Also discuss carefully the questions on biological oxygen demand in their guide.

Extensions:

If you have access to a test kit for dissolved oxygen, you can extend this activity by testing these water samples directly. Dissolved oxygen test kits are available from:

Hach Company Box 907 Ames, IA 50010



In the days before Washington was settled and the land was cleared, the Skokomish River ran through a deep forest. There are few places today where one can even see trees the size that once grew here. Over the last century nearly all of the original forests have been cut once or twice. Today, many other land uses now compete with trees for land here and all over Washington.

1. What effect could removal of forest cover have on the temperature of the water in rivers?

Water temperature is very important to salmon. One reason for this is that water temperature determines how much dissolved oxygen the water can hold.

2. Why is dissolved oxygen in the water important to salmon?

The following experiments will help you determine how changes in water temperature affect the oxygen available to fish.

You will need:

- a goldfish
- a quart jar containing room-temperature water
- · a quart jar containing refrigerated water
- a quart jar containing preheated, but cooled water
- · a stopwatch or watch with a second hand

Experiment I:

- **A.** Place a goldfish in the room-temperature water. Give it a minute to adjust to the jar.
- **B.** Time the number of "breaths" the goldfish takes in a 15-second interval. Record the results on your data sheet. Repeat this procedure at least 5 more times. Make at least 6 trials among your group and record the results of all the timings on your data sheet.
- **C.** Find the average of all the timings by adding all the counts made and dividing by the number of timings.

The next step is to change one variable, in this case temperature. Before we do, let's think about what we expect to observe.

3. If the fish were placed in water with less oxygen, how would you expect it to breathe? (How would you breathe if the air were thin?)

(circle) (1) more rapidly, or (2) more slowly

4. If the fish were placed in water with more oxygen, how do you think it would breath?

(circle) (1) more rapidly, or (2) more slowly

You will now repeat the experiment using chilled water. Before you begin, predict the change you expect in the fish's breathing rate when it is placed in colder water.

5. Write your prediction in the space below.

Experiment II:

Now repeat steps A, B, and C from Experiment I, this time placing the goldfish in the container of refrigerated water. Again record the results of at least 6 trials on your data sheet. Return the goldfish to its original jar.

6. What did you observe?

- **7.** From what you have observed, would you conclude that cold water contains more or less oxygen than room temperature water?
- **8.** What prediction would you make about the fish's breathing rate in warm water?

We will not actually place the fish in warm water, because that could cause the fish other serious damage. Instead, we can first heat water, then cover it tightly and let it cool to a temperature safe for the fish.

9. How will that keep its oxygen content from changing?

Experiment III:

Using the boiled water prepared earlier and cooled to room temperature, repeat the experiment exactly as before, recording your results on the data sheets and average your results. Return the fish to the classroom aquarium.

10. How did this trial compare with your prediction?

11.	What conclusions can you draw about the relationship of temperature to oxygen in the water?
12.	If the water temperature of a stream goes up, what could happen to the fish in the stream?
Biol	logical Oxygen Demand
	There is one other common way that water becomes low in dissolved oxygen. Organic matter is a name for substances produced by plants or animals, like sewage, manure, or sawdust. When organic matter gets into the water it begins to decompose or decay. As it decays, it combines with oxygen.
13.	When a large amount of organic material is allowed to decompose in a river or lake or even in Puget Sound, what will happen to the oxygen in the water?
14.	What effect could this have on fish and other animals which depend on dissolved oxygen?
15.	Name at least three things people do around Puget Sound which might cause organic matter to enter rivers, lakes, or Puget Sound.
	a.
	b.
	c.

14-4

WARMING	T UP DATA SHEET
Room Temperature Water	
Trial #1	
Trial #2	
Trial #3	
Trial #4	
Trial #5	
Trial #6	
Average	=
Chilled Water	
Trial #1	
Trial #2	
Trial #3	
Trial #4	
Trial #5	
Trial #6	
Average	_
Heated Water	
Trial #1	
Trial #2	
Trial #3	
Trial #4	. well a
Trial #5	
Trial #6	
Average	_