Teacher Guide: Pond Ecosystem

Learning Objectives

Students will:

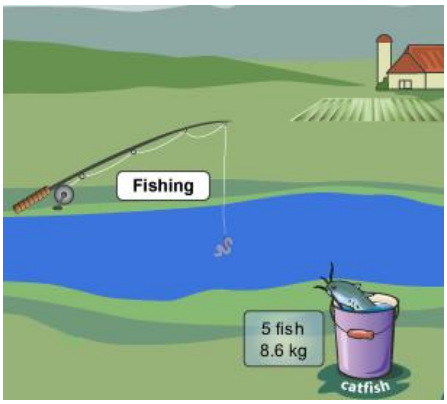
- Investigate how the levels of dissolved oxygen in a pond vary throughout a day.
- Learn the source of dissolved oxygen in a pond.
- Determine the effect of dissolved oxygen on the fish in a pond.
- Compare dissolved oxygen levels in warm and cold ponds.
- Determine the effect of farms on dissolved oxygen concentrations. (Extension)

Vocabulary

abiotic factor, biotic factor, concentration, mean, oxygen, parts per million, photosynthesis

Lesson Overview

In the *Pond Ecosystem* Gizmo™, students act as a field ecologist studying the life of a pond. Students measure temperature and dissolved oxygen levels, and then go fishing to see how these factors affect fish populations.



The Student Exploration sheet contains three activities:

- Activity A – Students observe how oxygen concentrations vary during the course of a day.
- Activity B – Students investigate the effects of oxygen concentrations on fish populations.
- Activity C – Students study the effect of temperature and farms on oxygen concentration.

Suggested Lesson Sequence

1. **Pre-Gizmo activity: Fun with cola** (10 – 20 minutes)

   Most students are familiar with solids such as sugar dissolving in water. The idea that gases dissolve in liquids may seem odd to them at first, but they see it every day!

   Show your students an unopened 2-liter bottle of soda or seltzer with the label removed. Allow the children to examine the bottle, and ask them where the bubbles are. In fact, the bubbles cannot be seen because the carbon dioxide gas is dissolved in the soda. Now place a balloon over the top of the soda bottle, and unscrew the cap underneath the balloon. Allow the balloon to fill with gas that is no longer dissolved in the soda. Ask your students why they see bubbles now, while they didn't see bubbles before.

   As a follow-up, use the balloon technique to compare the amount of gas produced by a cold soda bottle to a warm soda bottle. In theory, the balloon over the warm bottle will fill up more quickly because warm liquids cannot dissolve as much gas as cold liquids. For a spectacular demonstration, try dropping an entire roll of Mentos™ breath mints into a soda bottle. (Do this *outside*!) See **Selected Web Resources** for an amusing video of this experiment.

2. **Prior to using the Gizmo** (10 – 15 minutes)
   Before students are at the computers, pass out the Student Explorations and ask students to complete the Prior Knowledge Questions. Discuss student answers as a class, but do not provide correct answers at this point. Afterwards, if possible, use a projector to introduce the Gizmo and demonstrate its basic operations.

3. **Gizmo activities** (15 – 20 minutes per activity)
   Assign students to computers. Students can work individually or in small groups. Ask students to work through the activities in the Student Exploration using the Gizmo. Alternatively, you can use a projector and do the Exploration as a teacher-led activity.

4. **Discussion questions** (15 – 30 minutes)
   As students are working or just after they are done, discuss the following questions:
   - Do you think a pond gains more oxygen on a sunny day or a cloudy day?
   - Will the amount of oxygen in a glass of tap water increase during the day?
   - What are *two* effects of low levels of dissolved oxygen on the fish in a pond?
   - In general, catfish are bottom-feeders and trout like to live near the surface. In which location do you think dissolved oxygen is more abundant?
   - Suppose you are trying to figure out if a pond will support fish. What time of day should you measure the dissolved oxygen? Why?

5. **Follow-up activity: Investigate the effects of fertilizers** (1 – 2 weeks)
   Nutrient-rich *runoff* from farms can cause harmful algal blooms which deplete levels of oxygen in pond water. You can use liquid fertilizer to create your own algal blooms in the classroom.

   If possible, find water from a natural source such as a pond or stream. Try to get a sample that already contains algae. (If this is not available, you can buy algal cultures from science supply companies.) Fill two aquaria with this water.

   Place the aquaria where they will get plenty of sunlight. Label one tank “Fertilized,” and put a teaspoon of liquid fertilizer in it each day. Label the other tank “Unfertilized.” Over time algae will grow in both tanks, but the algae in the fertilized tank should be far more abundant. If you like, you can add several small fish to each tank. (Small bottom feeders such as pygmy corys work well.) Ask the students to compare the level of fish activity in the fertilized tank compared to the unfertilized tank.

Scientific Background

For animals that breathe air, the supply of oxygen is essentially endless. While availability of food or habitat may limit populations, oxygen availability is rarely an issue. For aquatic animals, especially those confined to a small body of water, oxygen availability is often the most important limiting factor. Plants, algae, and animals use oxygen constantly as they extract energy from their food, a process called *aerobic cellular respiration*.

In a pond, plants and algae replenish much of this oxygen during *photosynthesis*, when energy from the sun is used to convert carbon dioxide and water to sugar and oxygen. During daylight, plants and algae produce more oxygen than they use during respiration, so the concentration of

dissolved oxygen in the pond increases. At night, plants produce no oxygen because there is no light. Oxygen is still being used by all the plants and animals in the pond, so oxygen concentrations decrease until reaching a minimum at dawn.

Fish are highly sensitive to levels of dissolved oxygen. When oxygen concentrations are low, fish are less active and don't grow as large. In general, bottom-feeders such as catfish are tolerant of low-oxygen levels (2 – 4 ppm, short for "parts per million"), and can survive in conditions that would kill less tolerant species such as trout.

A variety of *abiotic* factors influence the concentration of dissolved oxygen in a pond. Hot water holds less oxygen just as hot soda holds less carbon dioxide. This may seems strange because hot water can hold *more* sugar. The rules for solids and gases dissolving in liquids are reversed because the extra energy in hot water helps gas particles break away and escape.

Fertilizers can have a significant effect on bodies of water because the extra nutrients can trigger a rapid growth of algae called an *algal bloom*. While this initially increases the oxygen level of the pond, the algae soon start to die. Bacteria use oxygen to decompose algae and the oxygen levels in the pond may plunge rapidly. This effect, called *eutrophication*, can kill fish and other organisms in the pond.

Environmental Connection

Algal blooms also occur in the ocean, with similar devastating effects. Often called *red tides* because of the red color of certain species of algae, these algal blooms can result in oxygen depletion, massive fish kills, and damage to other marine wildlife. As if this wasn't bad enough, some species of algae release toxic chemicals that poison fish and make seafood unsafe to eat.

Red tide off the coast of California

For decades, scientists have puzzled over the cause of the nearly annual red tides that occur in the relatively low-nutrient waters off Florida's west coast. Many theories have been proposed, including one suggesting that iron-rich dust from Africa is blown all the way across the Atlantic! In 2007, scientists proposed a more local source: nutrient-laden waters blown from the mouth of the Mississippi River.

Selected Web Resources

Pond resources: http://www.teachersnetwork.org/readysettech/seymour/ecosystem4.htm
Dissolved oxygen in ponds: http://aquaplant.tamu.edu/contents/dissolved_oxygen.htm
Water quality: http://www.ncsu.edu/sciencejunction/depot/experiments/water/lessons/do/
Mentos and Diet Coke video: http://eepybird.com/dcm1.html
Mentos demonstration instructions: http://app.tabblo.com/studio/stories/view/14370/
Building an Algal Bloom: http://www.bigelow.org/edhab/building_bloom.html
Harmful algal blooms: http://www.whoi.edu/redtide/page.do?pid=9257
FLA red tides: http://www.cop.noaa.gov/stressors/extremeevents/hab/features/florida_0406.html
Mississippi: http://news.nationalgeographic.com/news/2007/11/071108-AP-Red-Algae.html
Algal bloom news story: http://www.wtopnews.com/?nid=447&sid=608527