Mercury Bioaccumulation Tag

- **Grade Level**
  5-8
- **Subject Areas**
  Science
  Health
- **Duration**
  15 min for introduction
  15 min for activity
  15 min for wrap-up
- **Setting**
  Discussion: Classroom
  Activity: Outdoors
- **Skills**
  Gathering data
  Interpreting data
  Applying data
- **Vocabulary**
  Mercury
  Food chain
  Bioaccumulation
  Biomagnification
- **Related Websites**
  www.epa.gov/mercury
  www.epa.gov/children

Summary

Students will learn about the health effects of mercury. Students will model the processes of bioaccumulation and biomagnification in a food chain.

Objectives:

Students will:

- Understand how mercury accumulates in an organism and magnifies in a food chain.
- Describe the health effects of mercury.

Materials:

- Rope or cones to mark boundaries
- Colored paper tokens (at least 4 colors), cut into 2x2 inch size
- Cups of 4 varying sizes
- Pen/paper

National Science Content Standards:

- Unifying Concepts and Processes
  -Systems, order, and organization
  -Evidence, models, and explanation
  -Change, constancy, & measurement
- Life Science
  -Structure and function in living systems
  -Populations and ecosystems
- Science in Personal and Social Perspectives
  -Personal health
  -Populations, resources, and environments
  -Risks and benefits

Background:

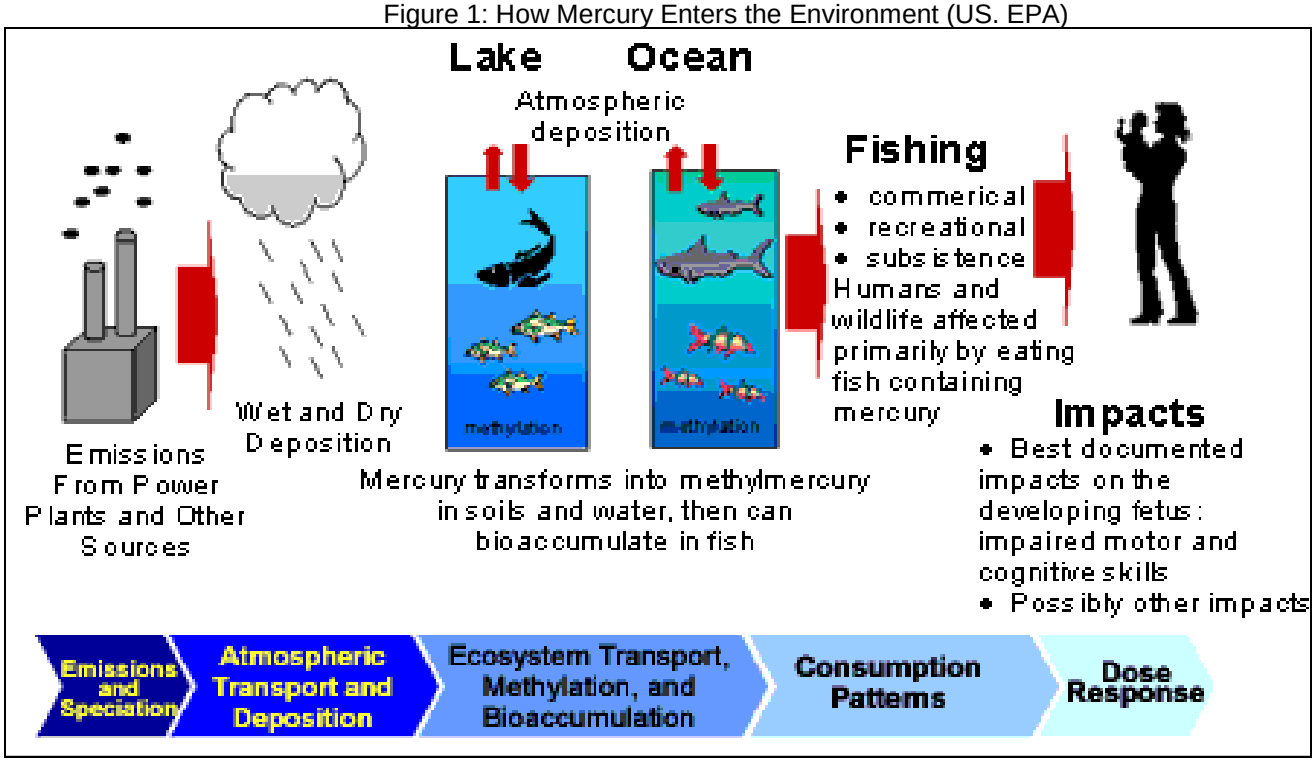
Mercury is a naturally occurring element (Hg) found in the Earth's crust. Common uses of mercury have included thermometers and compact fluorescent light bulbs. Mercury is also present in coal and when coal is burned, it is released into the air. This is the largest anthropogenic source of mercury in the environment in the United States. Other anthropogenic sources of mercury include manufacturing and industrial processes. Natural releases of mercury include volcanoes.

Mercury released into the air eventually settles in water or onto land, where it can be washed into water. Once deposited, certain organisms transform it into methylmercury, a highly toxic form that builds up in fish and shellfish. See Figure 1 for a representation of this process.

Methylmercury is a neurotoxin, meaning it affects the brain. The group most at risk for adverse health effects from methylmercury are developing fetuses, infants, and children. Methylmercury impairs neurological development and impacts cognitive thinking ability, memory, attention, language, fine motor skills, and visual spatial skills. Methylmercury can have similar impacts on adults, slowing neurological processes.

Methylmercury is taken up by tiny aquatic plants (plankton) and animals (zooplankton). These organisms are eaten by larger organisms, such as fish, and the concentration of methylmercury increases at each level of the food chain. For example, a large fish will have a higher concentration of methylmercury than a fish lower on the food chain. Top-level consumers have higher concentrations than low-level consumers and producers. For an

Figure 1: How Mercury Enters the Environment (US. EPA)



representation of this concept, see Figure 2. The process of taking in the contaminant, such as methylmercury and storing in the body is called bioaccumulation. As the concentrations increase with each level in the food chain, this process is called biomagnification. Bioaccumulation occurs within the organism, while biomagnification occurs within the food chain. Factors such as water pH, mercury concentration in the water, water temperature, and biodiversity all affect whether and to what extent bioaccumulation occurs.

Procedure:

Warm-Up:

Discuss with students what mercury is, where it is found, sources of, how it enters the environment, and what its health effects are. If needed, review or discuss what a food chain is. Show and discuss various land and aquatic food chains. Introduce the concepts of bioaccumulation and biomagnification.

Activity

1. Tell students they are going to model how methylmercury accumulates and magnifies in an aquatic food chain.
2. Mark off the boundary areas. Use an area large enough for students to move quickly. Distribute colored tokens around the entire area.
3. Give each student a cup and tell them what each size represents. Smallest cups represent plankton, the next size up represents small fish, the next size up represents large fish, and the largest cup represents eagles. See Table 1 for how large each group should be for a class size of 30 and adjust accordingly. (Note: When adjusting for your class size, make sure that the population of each level decreases as you go up the food chain. There should be more plankton than small fish, more small fish than big fish, and more big fish

Figure 2: Mercury becomes more concentrated up the food chain (U.S. EPA)

Table 1: Suggested Distribution of Organisms for a Class Size of 30	
Organism	Number of Students
Zooplankton	14
Small fish	9
Large fish	5
Bird of Prey	2
TOTAL	30

than birds of prey).

4. Inform students that the bounded area is a body of water. The tokens in the area represent food. On your mark, the plankton (the smallest cups) will go and feed. Plankton feed by picking up tokens and placing them inside their cups.
5. After all the plankton have fed, ask them to quickly tally their tokens, noting how many of each color, and replacing the tokens in their cups.
6. On your next mark, the small fish will feed on the plankton. Plankton will need to gather inside the bounded area. Small fish start on the outside of the area. On your mark, small fish will go up to the plankton and tag them. Once a plankton is tagged by a small fish, he/she must transfer the contents of the his/her cup to the small fish cup and exit the area. This represents that the plankton has been eaten by the small fish. (NOTE: A small fish may only tag one plankton at a time). Continue until there are no plankton left.
7. After there are no plankton left, ask the small fish to quickly tally their tokens, noting how many of each color and replacing the tokens in their cups.
8. Small fish gather inside the bounded area. Large fish gather on the outside. On your mark, large fish will feed on small fish. A large fish tags a small fish and the small fish must transfer his/her tokens to the large fish and exit the area. (NOTE: A large fish may only tag one small fish at a time).
9. After all the small fish are eaten, ask the large fish to tally their tokens, noting how many of each color.
10. On the final round, the large fish gather in the bounded area and the birds of prey gather on the outside. On your mark, the birds of prey will tag large fish. Upon being tagged, the large fish must transfer the contents of his/her cup to the bird of prey. Continue until there are no large fish left. (NOTE: A bird of prey may only tag one large fish at a time).
11. After all the large fish have been eaten, ask the birds of prey to tally their tokens, noting how many of each color.
12. Bring the students back to their seats. Ask them how the game went. Did it accurately model a food chain? Why or why not?
13. Tell them that the red tokens were not food: this was methylmercury that had entered the environment. Ask students to review over their tallies from the game. On the board, list all the plankton and how many red tokens each had, followed by small fish, large fish, and birds of prey.
14. Ask students to compare the tallies. Which organism had the highest levels of methylmercury? Why? (*Answer: The birds of prey have the highest levels of methylmercury. This is because as you move up the food chain, the same amount of methylmercury is transferred to a decreasing population, thus increasing the concentration in each organism.)*

Wrap Up

Discuss the activity with the following questions:

1. Where did the methylmercury come from? *The methylmercury was in the aquatic environment. It was mixed in with the food source. Plankton take in the methylmercury with their food and when they are eaten, the methylmercury is stored in the next organism.*
2. What assumptions did this activity make? *This activity assumes that all organisms in an ecosystem gets eaten. In an aquatic ecosystem, not all organisms would be exposed to methylmercury. As students may already know, ecosystems are made up of complex food webs. Methylmercury may not be present on all food chains in the food web. It also assumes that the conditions of the ecosystem are ideal for methylmercury to form and to be taken up*

with food (i.e.: the pH, temperature are right). Furthermore, this only represents a food chain.

3. What other top level consumers could we substitute for the birds of prey? *Top level consumers in this ecosystem include: humans, bears, etc. It is important to note that humans do eat high on the food chain and thus are at risk for any health effects.*
4. What health effects would the birds of prey have? What health effects might we see in humans if they ate the large fish? *If the birds of prey were exposed to a high concentration of mercury, they could experience death or severe neurological impacts. Methylmercury can cause diminished reproductive success, and can be detected in eggs laid by birds with high concentrations of methylmercury in their systems. These young can have serious deformities from the exposure to methylmercury. In humans, methylmercury can cause neurological damage, and have an impact on learning, memory, attention, and motor skills.*
5. What other contaminants might bioaccumulate? *Heavy metals, such as lead, pesticides such as DDT, and natural toxins, such as ciguatoxin produced by red algae.*
6. Explain the difference between bioaccumulation and biomagnification. *Bioaccumulation is the process by which a contaminant such as methylmercury is taken into an organism and its concentration increases within that organism as compared to the outside environment. Biomagnification is the process by which concentrations of a contaminant such as methylmercury increase as you move up the food chain.*
7. We modeled an aquatic food chain. Would this concept still apply to a terrestrial food chain? *Yes, if the contaminant is introduced lower in the food chain and has the potential to accumulate in the organism, then this representation would still be relevant in a terrestrial ecosystem.*

Assessment:

Assess students based on their performance in the activity. Use the wrap-up questions to evaluate the student knowledge gained in this activity.

Extensions:

1. Assign students contaminants to research that have the potential to bioaccumulate in an ecosystem. Examples include DDT and other pesticides, heavy metals, and natural toxins. What are the health effects of those contaminants? How are they similar or different to do the health effects of mercury?
2. Ask students to research fish advisories in their area. What type(s) of fish are generally safe to eat? What type(s) of fish should you limit consumption?

EPA Resources and Related Links:

Mercury. http://www.epa.gov/mercury/

Fish Advisories. http://www.epa.gov/mercury/advisories.htm

Fish Advisories Where You Live. http://www.epa.gov/waterscience/fish/states.htm

Student and Teacher Resources
http://www.epa.gov/students