# MOVING UP THE FOOD CHAIN

## OBJECTIVES

Students will be able to:

- give examples of ways that PCB and mercury contaminants move through the food chain
- describe possible consequences of PCB and mercury contaminants entering food chains
- describe how some human actions can have a long lasting negative impact on the health of the environment
- describe how human actions can improve the health of the Mississippi River environment.

**Grade Level:** 4 - 12

**Subjects:** Phy Ed, Science

**Duration:** 30 to 45 minutes

**Group Size:** > 10

**Setting:** Gym or playground

**Key Vocabulary:** bio-magnification

**Materials:**
- *3 different colors of tokens*
- *arm bands or labels*
- *paper bags or large envelopes*

## METHODS

Students become "eagles", "carp" and "mayfly nymphs" in a fast paced physical activity.

## BACKGROUND

The Mississippi River has a long history of being a center for human habitation, commerce, and industry. The legacy of human industrial activities along the river are sometimes more difficult to identify and may lay hidden beneath a small layer of mud in the form of contaminants that persist in the sediments of the Mississippi River.

The two most common contaminants, PCBs and mercury, were once commonly used in many industries. PCBs were used in the manufacture of electrical transformers, carbonless papers, cutting oils and hydraulic fluids. Mercury was used in the making of paints, agricultural chemicals, and in mining and smelting. Today, mercury mainly enters the environment as air pollution from the burning of coal. (Refer to the following for more information: introduction to Water Quality and Sedimentation, page WQ 3, and the background to Critter Contamination, pages WQ 23-25.)

Environmental laws, enacted in the 1970's and 80's have reduced the direct input of many harmful chemicals into the Mississippi River, but these chemicals still persist. Chemicals such as PCBs and mercury "attach" to particles of silt and clay on the bottom of the River. Over time, additional sedimentation covers the contaminated sediments, reducing the chance of these chemicals entering back into the water. However, burrowing animals absorb contaminants in sediments through their bodies. The contaminants can also be released back into the water

column through the burrowing activity of these animals, the feeding of fish and wildlife or resuspension due to wave action or current.

Aquatic organisms (i.e. invertebrates and fish) may absorb PCBs either through direct contact with contaminated sediment, from contaminated sediments suspended in the water and/or from their food (See Critter Contamination activity for more information). Mercury is absorbed by aquatic organisms directly from water passing over their gills or by ingesting other mercury-contaminated organisms. PCBs and mercury are extremely persistent and are easily passed along the food chain. The amount of mercury or PCBs found in an animal varies depending on species, age, size, fat content, where it lives and diet. For example, larger, older or predatory fish that have eaten many smaller fish may accumulate higher levels of PCB or mercury in their bodies.

PCBs and mercury can be harmful for many animals, including humans. PCBs have been linked to egg shell thinning in fish-eating predators such as cormorants, eagles and osprey. Fragile eggs can be crushed by the weight of the nesting parent. PCBs and mercury have been linked to developmental delays, learning disabilities, deformities and nervous system disorders in animals and humans.

Chemical contaminants are generally stored in the fat or tissues of animal bodies. Gradually, as you move up the food chain from the plant-eaters (primary consumers), to their predators, the secondary consumers, on up to their predators at the top of the food chain (tertiary consumers), you will see an increase in the amount of chemicals found (Figure 1). Scientists have coined this process "bio-magnification". For this reason, levels of contamination in fish are routinely monitored and published as fish consumption advisories to provide guidance on how many meals of fish a person may safely eat. These advisories are available on the websites for state natural resource agencies.

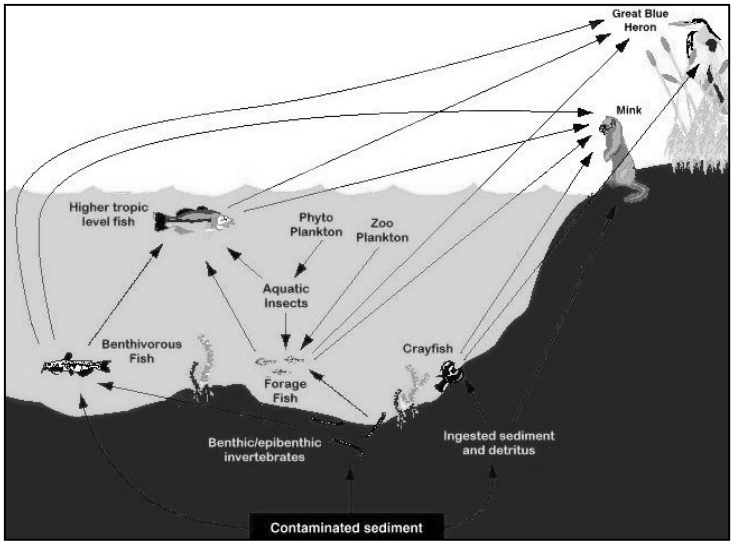


Figure 1. Food chain and process of bioaccumulation.
Source: http://www.epa.gov/reg5oh2o/fields/FIELDSITE/SHEBOYGN/PAGES/aqua_fig.htm

## MATERIALS

- Three different colors of tokens (straws, pipe cleaners, poker chips or any other material that students can pick up easily)
- 30 pieces per student is recommended in the following proportions (any 3 combination of colors will do):
    - 20 white
    - 5 purple
    - 5 green
- One bag per mayfly
- Optional: identification labels, tags or armbands for critters.

## PROCEDURES

1. Tell students that this is an activity about "food chains." If they are not familiar with the term, spend time in establishing a definition. (Food chain: a sequence or "chain" of living things in a community based on one member of the community eating the member below it, and so forth; i.e. mayfly nymph eats algae, carp eats mayfly nymph, eagle eats carp).

2. Divide the students into three groups. In a class of 26 students, there would be two "eagles," six "carp," and 18 "mayfly nymph." (Work with approximately three times as many carp as eagles and three times as many mayflies as carp.) Optional: have mayfly nymphs, carp and eagles labeled so they can easily be identified.

3. Hand each "mayfly nymph" a small paper bag or other small container. The container is to represent the "stomach" of whatever animal is holding it.

4. Distribute the food tokens around in a large open space and show the students the boundaries of the area they are to stay in.

5. Describe to the students how each of the animals in this simulation feed.

   **Mayfly nymphs** live in burrows they build into the bottom of the Mississippi River. Only their heads extend out of the burrow so that they can feed and get oxygen from the water. Since building a burrow for each nymph to hide in would be too time consuming, the nymphs in this simulation will be allowed to run around and collect their food instead of waiting for it to come to them. In nature, they would try to hide in the burrow to escape predators. However, today they can run from the predators as they continue to feed. *The mayfly nymphs will be first to feed by picking up token and placing their food into their stomachs (the bags or envelopes). If they are tagged, they will give this bag to a carp and move to the sidelines. The nymphs must continue to feed until they are tagged or the simulation ends.*

**Carp** would normally roam around the river looking for insect larvae, nymphs and plants to eat. While feeding, they would be moving slowly with their head down. Since it would be difficult to catch their food (the mayfly nymphs) in this simulation by roaming around with their head down (not to mention dangerous) they can run and tag they nymphs. *For the simulation, the mayfly nymphs will be allowed to feed for a while before the carp will begin to feed on them. So, have the carp wait on the sidelines in a school of fish until the signal is given for them to feed. When they tag a mayfly nymph, the nymph will give them their stomach and the nymph will go to the sideline. The carp should continue to feed until tagged by an eagle or the simulation ends. The carp must give its bags to the eagle if it is tagged and then move to the sidelines.*

**Eagles** either watch for their prey (carp in this simulation) from a perch or soaring over the water. When they see a carp, they swoop down to the water surface and grab it in their talons. For the simulation, the eagles will tag their prey (the carp) as the carp are feeding on the mayfly nymphs. *The eagles will be "perched" along the sidelines waiting for the signal for them to go feed on the carp. When the signal is given, they can enter the simulation and tag <u>only</u> the carp. When they tag a carp, they are to collect its stomach and continue to hunt.*

6. Begin the simulation by signaling for the nymphs to begin feeding. Following are the approximate times each group of students should have to feed. After the allotted time, signal the next group to begin feeding.

   Mayfly nymphs – 45 to 90 seconds depending on the size of area, or when about 50% of the food tokens have been collected.

   Carp -- 15 to 60 seconds depending on size of play area. Each carp should have an opportunity to catch one mayfly nymph. Don't allow enough time for all mayfly nymphs to be captured.

   Eagles – 15 to 60 seconds.

   End the simulation, and have them come sit down with their stomachs.

7. Ask the students who were eaten to identify what animal they were and which animal ate them. Next ask the eagles and surviving mayfly nymph and carp to empty their food bags out onto the floor and sort and count the food tokens by color. On a piece of paper chart the name of each animal and the number of each food token they have. For example:

| | Eagle A | Eagle B | Carp A | Carp B | Nymph A | Nymph B | etc. |
|---|---|---|---|---|---|---|---|

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| White | 45 | 60 | 30 | 32 | 12 | 6 | |
| Purple | 2 | 12 | 9 | 6 | 0 | 8 | |
| Green | 2 | 10 | 3 | 16 | 0 | 3 | |

8. Inform the students that there are contaminants in the environment. These contaminants can be dangerous for animals to eat, accumulate in food chains and staying in the environment for a long time. Explain to them that these contaminants were used in the manufacturing of various items and found their way into the environment years ago before laws limiting their use were passed. These contaminants are still found in the sediment, or mud, on the bottom of the Mississippi River, particularly near larger cities. The mayfly nymph "ate" these contaminants as they were feeding on the algae; however, not all of the algae had contaminants associated with them. In this activity, the purple and green food tokens represented the contaminants mercury and PCBs. Below is what happens to the animals based on the number of contaminants they consumed.

| **Animal** | **Total Number of Contaminated Food Pieces (green and purple)** | **Fate** |
|---|---|---|
| Mayfly Nymph | $\geq$ 4 | Died because it was unable to transform into an adult |
| Carp | $\geq$ 30 | Died or was unsuccessful at spawning due to poor egg development |
| Eagle | The eagle with the most<br><br>In the second simulation, both of the eagles show no ill affect (unless one gets all of the contaminated food pieces, then its reproduction and health is affected). | The eagle with the most contaminants will not die at this time; however, it has accumulated so much of the contaminants in its body that the egg shells produced by it and its mate during the next nesting season will be so thin that the eggs will not hatch successfully.<br><br>The other eagle was not visibly affected. |

9. Ask the students to describe what they just experienced in the activity. Discussion should focus on:

   - examples of a food chain
   - how contaminants entered and moved through the food chain
   - effects of PCB and mercury in the food chain

10. Have the students discuss how historical human actions have caused contaminants to bioaccumulate in the Mississippi River ecosystem. Ask them about what humans have done to reduce contamination of the

Mississippi River (i.e. banned the manufacture of PCBs and started recycling batteries).

11. Replay the activity by having only one of the colors representing contaminated food, the other color now becomes just food. In step 8 tell them that human actions they listed in 10 have reduced the levels of PCBs and mercury in the water. Draw a new chart and discuss the differences between the two simulations.

12. Have students discuss how humans may be impacted by biomagnification on the Mississippi River (i.e. fish consumption advisories, affects on recreational activities like bird watching).

13. Look up the fish consumption advisory for a certain section of the Mississippi River. Note varying advisories depending on location along the river. Emphasize that the advisory does not discourage fish consumption but provides guidelines for safe consumption.

## EXTENSIONS

As a pre-activity, do Critter Contamination to illustrate how PCB contamination in mayfly nymphs is more prevalent near or downstream of population centers where industry is more prevalent.

Have older students read "Silent Spring" by Rachel Carson, or read certain passages to the class. Silent Spring describes the impact of another form of pollution that was used in industry and agriculture and had impacts similar to PCBs.

## ASSESSMENT

1. Name 2 types and sources of contaminants that can enter the food chain on the Mississippi River. (PCBs entered the food chain of the Mississippi River due to past uses and disposal of contaminated items. Mercury enters into the environment from industry and improper disposal of some types of batteries.)

2. How can PCBs and mercury move through the food chain? (Through bioaccumulation and biomagnification).

3. What are some impacts of contaminants in the food chain? (Reduced reproduction, poor health of animals, death, etc.)

4. What actions can humans take to reduce past or prevent future introduction of contaminants into the environment? (Laws have been passed to stop the use of some chemicals. Other laws, like the Clean Water Act, have paved

the way to set limits on the introduction of contaminants into the environment.  Some sites that were heavily contaminated by past practices have been cleaned up, or people have constructed projects to prevent contaminants in the area from leaking into the environment.)