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Mercury Poisoning

Part I: Minamata Disease

1. Read the information in the box below. As you read, underline the symptoms associated with mercury poisoning in humans.

Minamata Disease — A Case of Mercury Poisoning

"Minamata disease" is the term used to describe the mercury poisoning that occurred among residents of Minamata, a small Japanese fishing village. It started out with the strangeness of cats "dancing" in the streets before collapsing and dying. Then, people in Minamata began exhibiting symptoms such as numbness and pain in hands and feet, blindness or double vision, uncontrollable shaking or tremors, loss of coordination and balance, partial paralysis, and memory loss. Some mothers with no symptoms of nervous system damage gave birth to infants with severe disabilities.

1. Complete Column A in the chart below by writing six symptoms that indicate how mercury poisoning damages the nervous system in humans.

Column A	Column B
Symptom of Mercury Poisoning	Part of Nervous System Affected to Produce Symptoms

2. Your lab kit contains a sheet with a "Nervous System Function" chart and "Parts of the Nervous system Damaged by Mercury" diagram. Use the information on this sheet to complete Column B of the chart by writing the part of the nervous system that, if damaged, would produce each symptom of mercury poisoning. Hint: You only need to indicate one part that might result in each symptom.

3. What information in the reading suggests that the nervous system of a developing baby is more vulnerable to mercury poisoning than the adult's nervous system?

_____

_____

Part 2: Mercury in the Ecosystem

1. Read the information in the box below. As you read, underline the names of living organisms in the Minamata ecosystem that might be affected by mercury.

Minamata Disease — An Ecological Problem

A chemical factory in Minamata dumped wastes containing mercury into Minamata Bay. The mercury entered the food web in the bay when it was absorbed by phytoplankton (microscopic floating plants). The phytoplankton was eaten by zooplankton (microscopic floating animals). The zooplankton was eaten by shrimp and shellfish (clams and oysters). The shrimp and shellfish were eaten by small fish. The small fish were eaten by larger fish. The mercury in seafood posed a significant health hazard to humans of the Minamata village who obtained much of their protein by eating shellfish, shrimp, small fish, and large fish from Minamata Bay.

2. The "Organism Cards" sheet in your kit represents the organisms in the Minamata Bay ecosystem. Cut along the dotted lines to create a set of "Organism Cards."

3. Use the information in the reading to place the "Organism Cards" in the appropriate boxes on the "Food Web Diagram" on page 11. Tape or glue each of the "Organism Cards" to the correct box on the "Food Web Diagram."

4. Producers (or autotrophs) can convert light energy into food energy. Which organisms in the chart are autotrophs? _____

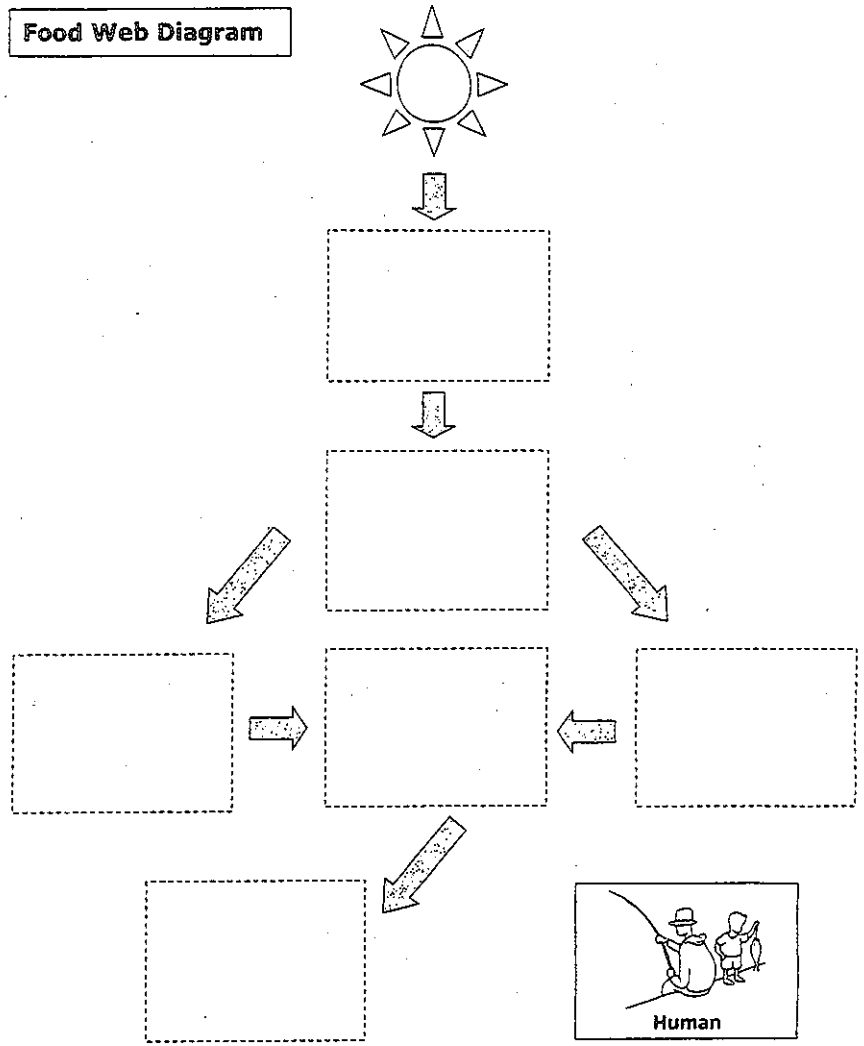
5. Consumers (or heterotrophs) cannot make their own food. Instead, they need to eat other organisms as a source of food energy. Which organisms in the chart are heterotrophs?

_____

6. Draw four arrows on the Food Web Diagram to show the four routes that mercury in this ecosystem might take to end up in a human.

7. Which food source for humans do you think would contain the highest concentration of mercury—shrimp, shellfish, small fish, or large fish? _____

Food Web Diagram



Part 3: Modeling Energy and Mercury Transfer in an Ecosystem

In Part 3, you will use a model to illustrate the transfer of energy and mercury through a food chain in the Minamata ecosystem. In this model:

- **Cups** represent the relative numbers of organisms at each feeding level of a food chain. The size of the cups indicates the relative **numbers of organisms** at each feeding level. Notice that, as food is passed from the producer level through a series of consumers, each feeding level has fewer organisms.
- **Water** in the cups represents **energy** stored in food that is passed from one feeding level to another. When food energy is transferred (through eating), only 10% of the food energy is transferred from one feeding level to the next. The remaining 90% of the food energy is used for life activities and eventually lost as heat.
- **The silver bead represents mercury** in the food chain that is passed from one feeding level to another. Food may be contaminated with toxins. Toxins such mercury, lead, or pesticides, are <u>not</u> lost as they are transferred from one feeding level to another.

1. What will the cups in your model represent?

   _____

2. Why will you use cups that are different sizes?

   _____

3. What will the water in your model represent? _____

4. What will the silver bead in your model represent? _____

5. Observe the pyramid diagram **Modeling Energy and Mercury Transfer in an Ecosystem** (on the last page). Why is each feeding level a different size on this pyramid?

   _____

6. Set up an ecosystem model by putting the following materials into the green cup labeled "10,000 Phytoplankton":
   - Use the large measuring cup to fill the green "10,000 Phytoplankton" cup with 400 mL of water to represent the food Energy in the phytoplankton. Record the amount of water (energy) in the phytoplankton cup in the phytoplankton box of the energy pyramid diagram.

7. Place one silver bead from the "Mercury" bag into the green cup. The silver bead represents mercury that the phytoplankton absorb from the water.

8. The phytoplankton are eaten by zooplankton.
   - Transfer 10% of the energy (40 mL of water) into the "1,000 Zooplankton" cup. Represent the loss of energy from the food chain by discarding the remainder of the water into the red cup labeled "Energy used for life activities and eventually lost as heat." Record the amount of water in the zooplankton cup in the zooplankton level on the energy pyramid diagram. Be sure to catch the bead as you pour the water out of the cup.
   - Transfer the mercury (silver bead) into the "1,000 Zooplankton" cup.

9. The zooplankton are eaten by the shrimp.
   - Transfer 10% of the energy (approximately 4 mL of water) into the "100 Shrimp" cup. Represent the loss of energy from the food chain by discarding the remainder of the water into the red cup labeled "Energy used for life activities and eventually lost as heat." Record the amount of water in the shrimp cup in the appropriate box on the energy pyramid diagram. Be sure to catch the bead as you pour the water out of the cup.
   - Transfer the mercury (silver bead) into the "100 Shrimp" cup.

10. The shrimp are eaten by the small fish.
   - Transfer 10% of the energy (approximately 0.4 mL of water) into the "10 Small Fish" cup. Represent the loss of energy from the food chain by discarding the remainder of the water into the red cup. Record the amount of water in the small fish cup in the appropriate box on the energy pyramid diagram. Be sure to catch the bead as you pour the water out of the cup.
   - Transfer the mercury (silver bead) into the "10 Small Fish" cup.

11. The small fish are eaten by large fish.
    - Transfer 10% of the energy (approximately 0.04 mL of water ≈ 4 drops) into the "1 Large Fish" cup. Represent the loss of energy from the food chain by discarding the remainder of the water into the red cup. Record the amount of water in the large fish cup in the appropriate box on the energy pyramid diagram. Be sure to catch the bead as you pour the water out of the cup.
    - Transfer the mercury (silver bead) into the "1 Large Fish" cup.

12. What does pouring the water from a larger cup into a smaller cup represent?

    _____

13. What does discarding the water represent?

    _____

14. You started with 400 mL of water in this model. How much of the original amount of water:
    - Ended up in the "1 Large Fish" cup. _____ mL
    - Was discarded. _____ mL

15. What happens to the amount of energy in the organisms as the energy is passed from one feeding level to another in the food chain?

    _____

16. Explain why it takes thousands of producers to support one human in a food pyramid.

    _____

17. What does pouring the bead from one larger cup into a smaller cup represent?

    _____

18. You started with one silver bead in the large green cup.
    - How many silver beads ended up in the "1 Large Fish" cup? _____
    - How many silver beads were lost (discarded)? _____

19. Calculate the concentration of mercury at each level of the food chain.

    Concentration = number of mercury beads/number of organisms

    Record the mercury concentration that you calculate (beads/organism) on the appropriate levels of the pyramid diagram.

20. What happens to the concentration of mercury as mercury flows through the food chain?

    _____

21. Return the silver bead to "Mercury" bag. Dry the cups. Return the bag of beads and the cups to the kit bag.

> **Biological Magnification** or **biomagnification** is the process in which certain substances such as pesticides or heavy metals, such as mercury or lead, move up the food chain. The substances become concentrated in tissues or internal organs as they move up the chain.

22. Read the definition of "biological magnification" (above). Explain how this modeling activity with mercury (silver bead) illustrates the process of biomagnification.

    _____

    _____

23. Humans may eat a variety of seafood. Which type of seafood would be most dangerous to eat because it contains the largest concentration of mercury—large fish, small fish, or shrimp? Use information from your model to support your answer.

    _____

    _____

24. Which type of seafood (large fish, small fish, or shrimp) would be safest for people to eat because they contain lower concentrations of mercury?

    _____

25. Explain why mercury in the ecosystem may harm humans yet have no apparent harmful effects on the plankton, shrimp, small fish, and large fish.

    _____

    _____

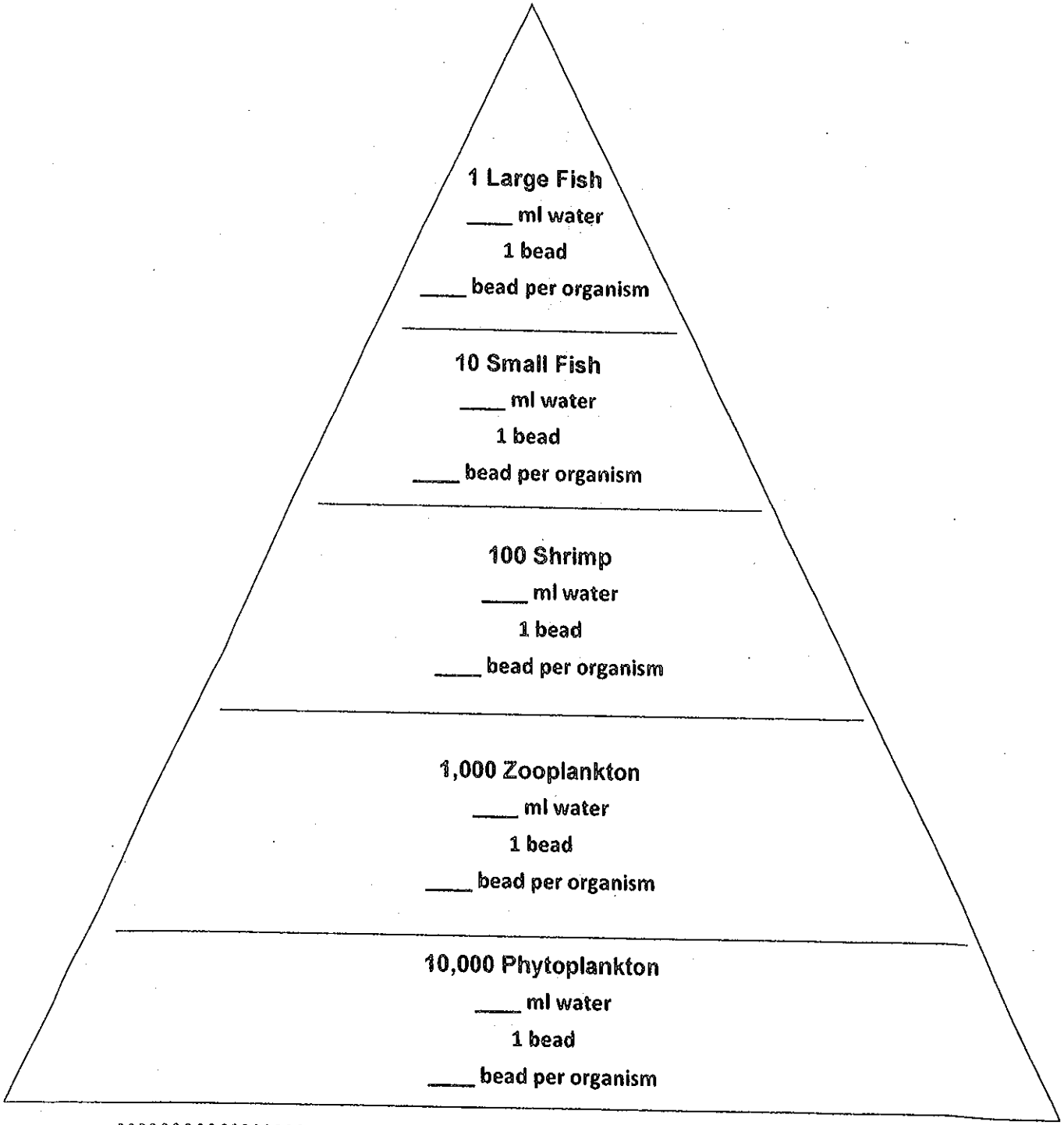
26. What does the model that you used suggest to a person who is concerned about health and choosing whether to eat a plant-rich or animal-rich diet?

    _____

    _____

Modeling Energy and Mercury Transfer in an Ecosystem

Water in the model represents **energy**
Bead in the model represents **mercury**



Part 4: Should People Avoid Eating Fish and Shellfish?

Should you be concerned about eating fish or shellfish that may contain mercury? The Food and Drug Administration (FDA) and the Environmental Protection Agency (EPA) have provided guidelines for people about eating fish and shellfish. Read the advice they provide below.

FDA and EPA Advice For:

Women Who Might Become Pregnant - Women Who are Pregnant - Nursing Mothers - Young Children

Fish and shellfish are an important part of a healthy diet. Fish and shellfish contain high-quality protein and other essential nutrients, are low in saturated fat, and contain omega-3 fatty acids. A well-balanced diet that includes a variety of fish and shellfish can contribute to heart health and childrens' proper growth and development. So, women and young children in particular should include fish or shellfish in their diets due to the many nutritional benefits.

However, nearly all fish and shellfish contain traces of mercury. For most adults, the risk from mercury when eating fish and shellfish is not a health concern. Yet, some fish and shellfish contain higher levels of mercury that may harm an unborn baby or young child's developing nervous system. The risks from mercury in fish and shellfish depend on the amount of fish and shellfish eaten and the levels of mercury in the fish and shellfish. Therefore, the Food and Drug Administration (FDA) and the Environmental Protection Agency (EPA) are advising women who may become pregnant, pregnant women, nursing mothers, and young children to avoid some types of fish and eat fish and shellfish that are lower in mercury.

By following these three recommendations for selecting and eating fish or shellfish, women and young children will receive the benefits of eating fish and shellfish and be confident that they have reduced their exposure to the harmful effects of mercury.

1. Do not eat shark, swordfish, king mackerel, or tilefish because they contain high levels of mercury.
2. Eat up to 12 ounces (2 average meals) a week of a variety of fish and shellfish that are lower in mercury.
   - Five of the most commonly eaten fish that are low in mercury are shrimp, canned light tuna, salmon, pollock, and catfish.
   - Another commonly eaten fish, albacore ("white") tuna has more mercury than canned light tuna. So, when choosing your two meals of fish and shellfish, you may eat up to 6 ounces (one average meal) of albacore tuna per week.
3. Check local advisories about the safety of fish caught by family and friends in your local lakes, rivers, and coastal areas. If no advice is available, eat up to 6 ounces (one average meal) per week of fish you catch from local waters, but don't consume any other fish during that week. Follow these same recommendations when feeding fish and shellfish to young children, but serve smaller portions.

Source: http://water.epa.gov/scitech/swguidance/fishshellfish/outreach/factsheet.cfm#consumers

1. Nearly all fish and shellfish contain traces of mercury. Why do the FDA and EPA recommend that people eat fish and shellfish as an important part of a healthy diet?

2. Why do the FDA and EPA discourage eating larger fish (swordfish, shark, king mackerel and tilefish)?

3. What kinds of fish are safer to eat because they are lower in mercury?

4. Why is it suggested that women who may become pregnant, pregnant women, nursing mothers, and young children limit the amount of fish they eat to 12 ounces per week?

If you have questions about the safety of eating fish, visit the following websites for more detailed information.

- What You Need to Know about Mercury in Fish and Shellfish http://water.epa.gov/scitech/swguidance/fishshellfish/outreach/advice_index.cfm
- Fish Consumption Advisories http://www.epa.gov/hg/advisories.htm
- Consumer Information about Seafood http://www.fda.gov/Food/FoodSafety/Product-SpecificInformation/Seafood/ConsumerInformationAboutSeafood/default.htm