RESEARCH TRIANGLE NANOTECHNOLOGY NETWORK

A Different Kind of Serial Killer

Serial Killer–Bio-Disruptors: A lesson on biomagnification

Tell your students at the beginning of the year that Earth Science is a long conversation about Earth's natural processes and what humans are doing to mess them up. Biomagnification is one small part of this.

At the conclusion of the lesson, students will have a clearer understanding of how toxins move through ecosystems and the impact they have on organisms.

Overview

In this lesson we will discuss how human activities produce waste that ends up in our environment, (e.g, soil, water), and the negative effects on the organisms and threat to biodiversity. Students will gain an understanding of how unseen toxins accumulate in organisms of various ecosystems after completing the serial dilution activity, One Part per Billion.

Students will be able to make connections between toxins in the environment and how they can affect the organisms who live in them.

Key Search Words

Earth Science, 9th Grade, Ecology, Pollution, Biomagnification, Bioaccumulation, Organisms, Energy pyramid, Energy Flow, Trophic Levels, Food Webs, Dilution, Magnification

Learning Objectives

- The learner will be able to explain how human activities contribute to the build-up of toxins in living organisms.
- The learner will be able to describe how toxins accumulate in organisms that make up various ecosystems.
- The learner will be able to infer the relationship between bioaccumulation and its effects on the human population.

Curriculum Alignment

HS-LS2-2 Use mathematical representations of phenomena or design solutions to support and revise explanations. about factors affecting biodiversity and populations in ecosystems of different scales.

Related North Carolina Essential Standards

- EEn.2.7.3 Explain how human activities impact the biosphere.
- EEn.2.4.2 Evaluate human influences on water quality in North Carolina's river basins, wetlands and tidal environments

Classroom time required

- Tentatively, one block (90 minutes) should be sufficient to present the lesson, if extra time is needed, adjust as necessary.

Materials & Technology

- 9 cups
- Food color
- Mix Solution
- Droppers
- Mouth wash
- 200 mL water
- Graduated cylinders
- Student Data Sheet
- White paper

- Amoeba sisters video, “Biomagnification and the trouble with toxins” video (https://www.youtube.com/watch?v=TZk6vcmLcKw)
- Biomanbio.com, ecology, the Peril River-if time permits (video game style interactive that addresses biomagnification along with other human activity related problems that affect our environment)

Safety
Lab goggles should be worn during the activity.

Teacher Preparation for Activity
Review food chains/ food webs/ energy and trophic pyramids
Distribute materials for the activity: One Part Per Billion

Student Preparation for Activity (prior knowledge)
- Students will have already learned about food webs/ chains, and discussed energy transfer/flow.
- Students will have knowledge of energy pyramids, Biomass pyramids, and pyramids of numbers.
- Students will have learned about sources of pollution (point-source and nonpoint-source pollution).

Procedure
Serial Dilution Activity Procedure:

1. Place 9mL of water in each of the 9 cups

2. In cup #1 (farthest from the left), place 1mL of food coloring, mix the food coloring and water solution by swirling the cup gently.

3. Describe the color and calculate concentration of the food coloring and water solution .

4. Next, add 1 mL of solution from cup #1 into cup #2 and mix the new solution together by swirling gently.

5. Describe the color and calculate concentration of solution. (See table on handout)

6. In cup #3, add 1mL of the solution from cup 2, mix this new solution.

7. Describe the color and calculate concentration of the solution in cup 3.

8. Repeat dilution process as done before for cups 4-9 .

To save time, this can be done as a teacher demonstration for students in small groups.

This activity can be easily related to the build-up (biomagnification) of a toxin in an organism, and the accumulation (biomagnification) of a toxin up a food chain, starting with the tiniest amount in a stable ecosystem.

**This activity was adapted from the Parts per Billion activity in the Extreme Science from Nano to Galactic Book.

Differentiation
Exceptional (EC) students may need extended time to complete this assignment. This can be an accommodation that is given to students as needed.

Collaborative learning is encouraged, students are paired up or placed in groups during manipulative activities such as this one. Students will demonstrate understanding by creating a group poster, comic strip, or power-point flip book.

Assessment/Check for Understanding
Students may choose one of the following assignments at the conclusion of the activity.

The selected assignment must include the following:

1. Choose an ecosystem (land or water).

2. Select an organism for each trophic level (should include at least 4 levels).

3. Label the diagram correctly by drawing lines in the direction of the flow of toxin increase.

4. Show numerically the quantity increase (you may use your data from the activity or a fictional quantity).

- Student(s) will create a biomagnification poster. (Poster will show an introduction of a toxin, the organisms involved, the parts per billion (ppb) transferred as each organism is consumed.)
- Student(s) will create a comic strip showing the accumulation of a toxin through a food chain.
- Student(s) will create a powerpoint flip book.

Students whose poster, comic strip, or powerpoint flip book does not show all aspects or may be missing a step, can complete the quiz below (which is more of a review of concepts with explanation).

> https://quizizz.com/Biomagnification Quiz (students can retake the quiz; you may want to use this pre-existing quiz or make your own).

Required resources

- One Part per Billion student data sheets, poster paper, colored paper, colored pencils/markers, computer
- https://www.biologycorner.com/2020/03/25/biological-magnification/

Author comments

- I chose this lesson to give my students a hands-on visual to see how toxins can enter and move up a closed system.
- The serial dilution activity, One Part per Billion will serve as a visual reinforcement before or after the lesson of food chains/webs and energy transfer is taught. They will learn that not only will energy be passed on, but also anything that is introduced in the environment can be passed on from one organism to another.

Sources

biomanbio.com (ecology/the peril river interactive)

youtube.com (amoeba sisters)

https://www.biologycorner.com/2020/03/25/biological-magnification/

https://quizizz.com/Biomagnification Quiz

Jones, G. et al (2009). Extreme Science from Nano to Galactic (1st. ed.). NSTA Press**

Appendices

https://www.biologycorner.com/2020/03/25/biological-magnification/

One Part Per Billion

Background:

This activity will be used to demonstrate biomagnification and bioaccumulation. **Biomagnification** is the increase of a toxin up a food chain as organisms are eating and being eaten. **Bioaccumulation** is the increase of a toxin in the tissues of an organism.

The following lab demonstration will show the accumulation of a “toxin” after it ends up in soil or a large water source due to human activities. It will be demonstrated using a dilution activity. After the substance is diluted through the gradual reduction of the sample, the ecology connection will be made by substituting each cup for an organism in a food chain, and looking at the demonstration by reversing the “flow” towards the more concentrated solution.

Pre lab Questions:

1. Define dilution, accumulation, toxin
2. How does biomagnification differ from bioaccumulation?

Materials:

Each group will need:

- ☐ 1mL dropper
- ☐ Food coloring
- ☐ 200 mL of water
- ☐ Rinse cup of water
- ☐ 9 small clear (or white) cups or beakers
- ☐ 1 mL of mouthwash (to be used during the extend part of the lesson)
- ☐ (2) 10 mL graduated cylinders,
- ☐ student data sheet

Procedure:

1. Place 9 mL of water in 9 cups

2. In cup #1 (farthest from the left), place 1mL of food coloring. Mix the food coloring and water solution.

3. Describe the color and calculate the concentration of the food coloring and water solution.

4. Next, add 1 mL of the solution from cup #1 into cup #2 and mix the new solution together.

5. Describe the color and calculate the concentration of the solution. (See table below)

6. In cup #3, add 1mL of the solution from cup 2, and mix this new solution.

7. Describe the color and calculate the concentration of the solution in cup 3.

8. Repeat dilution process as done before for cups 4-9.

Data:

Record the color change after each dilution. Note the corresponding concentration.

Cup	Color	Concentration	Fraction	Trophic Level
1.		0.1	1/10	Apex predator
2.		0.01	1/100	Tertiary Consumers
3.		0.001	1/1000	
4.		0.0001	1/10,000	Secondary Consumers
5.		0.00001	1/100.000	
6.		0.000001	1/1,000000	Primary Consumers
7.		0.0000001	1/10,000000	
8.		0.00000001	1/100,000,000	
9.		0.000000001	1/1,000,000,000	Producer

Conclusion:
1. What cup did the toxin (color) appear colorless?
(students may answer cup 5)

2. Is there any food color in each of the solutions?

(students should answer yes, even though it is not visible to the naked eye)

3.How do you think the concentration of the toxin would affect the organism who possess colored levels of toxins compared to the organisms who possess clear levels of the toxin?

(answers may vary, students should answer in terms of concentrated levels of toxins)

4. If an aquatic ecosystem contained the same amount of toxin as cup nine, would there be cause for concern? Why or why not?

(students should answer in terms of the toxin accumulation up a food chain as organism are eaten and being eaten)

5. In a simple food chain, which organism would be affected the most?

(students should select the organism at the top of the food chain, since it would have the most build-up)

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4. In cup #2, add 1 mL of the food coloring and water solution from cup 1, and mix the new solution together.

5. Describe the color and calculate the concentration of the solution. (See table below)

6. In cup #3, add 1mL of the solution from cup 2, and mix this new solution.

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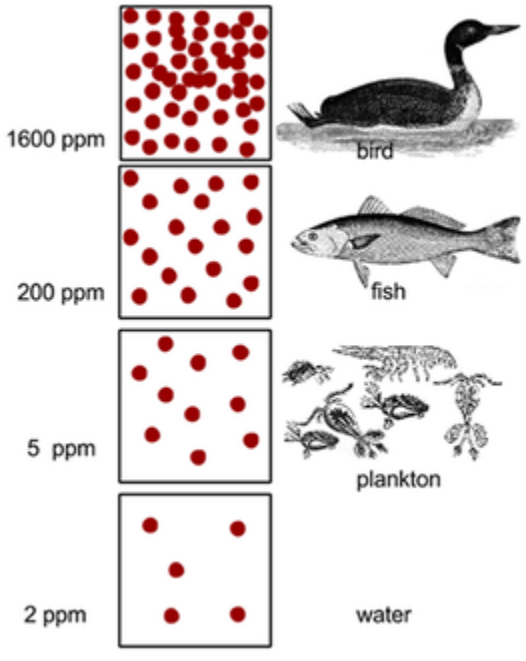
N

What is Biological Magnification?

Biological magnification refers to the process where toxic substances move up the food chain and become more concentrated at each level. These substances are often pollutants from industries or pesticides from farming. An example of biological magnification and its dangers is any small fish that eats plankton that has been tainted with mercury. Hundreds of small fish might then contain just a few parts of the mercury, not enough to cause major harm. The amount of mercury is measured in ppm, which means "parts per million."

A bird then might eat hundreds of the small fish, so that now instead of 200 ppm in a single fish, that bird has much higher levels of mercury. The toxin amplifies as it moves up the food chain.

Biological magnification caused a crisis with eagles, where DDT was used to control mosquitoes and other pests. Birds would accumulate toxic levels of DDT in their bodies which would cause their eggs to become fragile and break. The eagle almost became extinct, but lawmakers banned DDT and the eagle is now in recovery.



A. Finding Information: *Scan the article for answers to specific questions*.

1. What does PPM mean? _____
2. What chemical caused the decline of the eagle population? _____

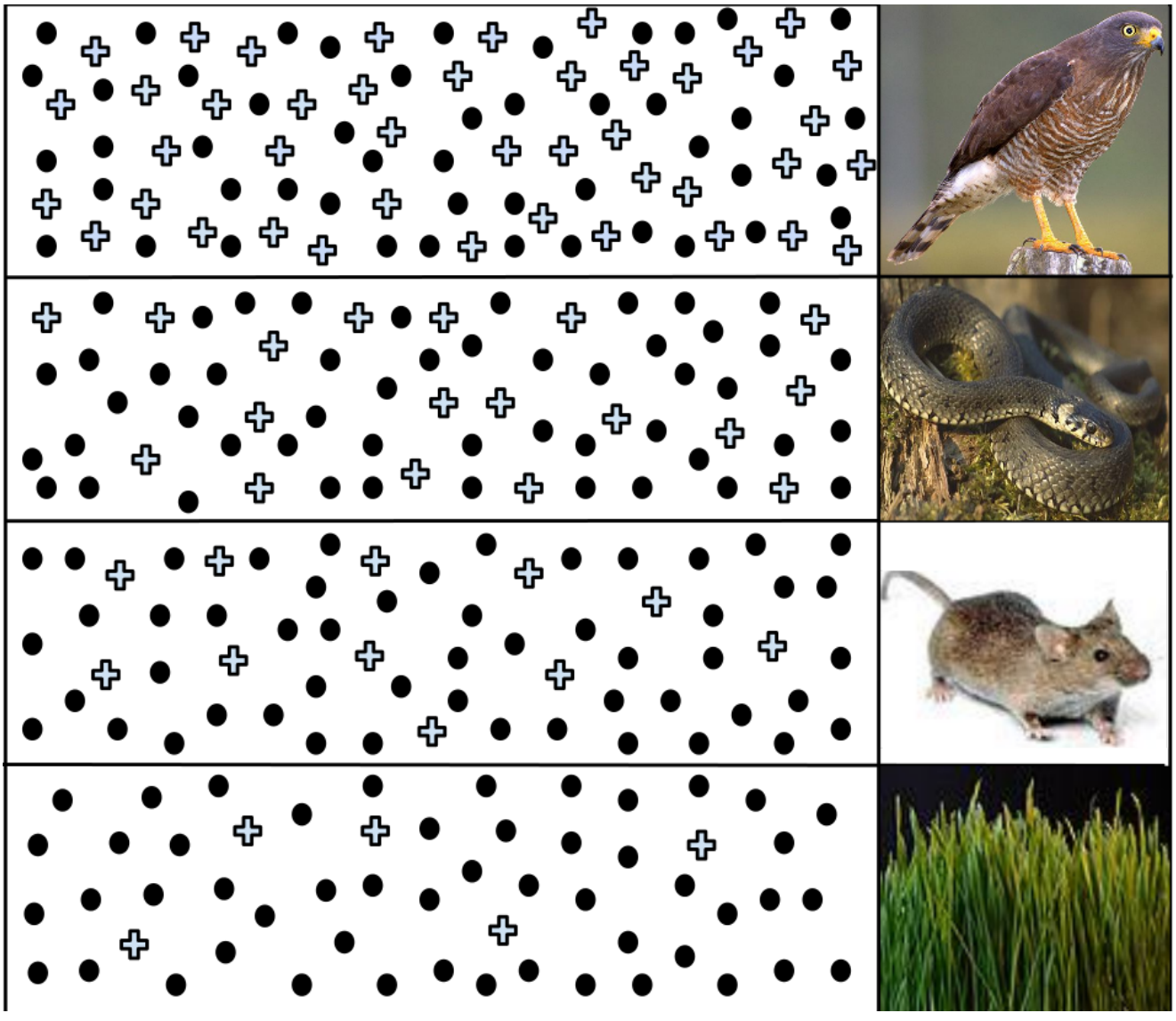
B. Locating evidence and supporting statements. *These things are not specifically said*.

3. Based on the claims made in the passage, biological magnification is a result of:
   a) pollution b) climate change c) food shortages d) extinction
4. What saved the eagle population? a) captive breeding b) laws banning DDT c) habitat change
5. What type of animals are most affected by biological magnification?
   a) herbivores b) omnivores c) aquatic organisms d) top predators
6. What is the author's purpose or point in this writing?
   a) to convince readers to stop pollution b) to explain the process of biological magnification
   c) to compare the effects of mercury and DDT d) to describe the effects of mercury poisoning

C. Using Context Clues. *Are there words in the passage that you don't understand? Good readers learn to use clues to guess at the meanings of words they don't know.*

7. What is plankton? a) a type of toxin b) tiny animals c) a type of bird
8. What does amplify mean? a) to be able to hear b) become sick c) make larger
9. What does accumulate mean? a) to increase b) to chase c) to destroy
10. What does tainted mean? a) colorful b) contaminated c) extinct

D. Application - Using what you have learned to apply to a new situation



11. If the + icons in the image represent a toxic substance. Explain why the hawk is most at risk for being affected by this substance.

12. Pregnant women are advised to limit the amount of fish they eat during pregnancy due to the high amounts of mercury found in some types of fish. If the amount of pollution is the same in the ocean where the fish are being caught, why might some fish have more of this toxin than others?

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Vocabulary List

Term	Definition
Pollution	Harmful materials or substances introduced into an environment by human activity
Biomagnification	is the increase of a toxin up a food chain as organisms are eating and being eaten
Bioaccumulation	is the increase of a toxin in the tissues of an organism.
Organisms	A plant or animal living in an ecosystem
Energy Flow,	The flow of energy through organisms in an ecosystem
Energy pyramid	Energy flow model showing the transfer of energy from one trophic level to another
Trophic Levels	Level organism occupy in a food chain/web
Food Webs	community of organisms where each member is eaten and being eaten
Dilution	Decrease in concentration of a substance
Magnification	Increase in concentration of a substance
Ecology	study of the relationship between organisms and their environment