NATIONAL GEOGRAPHIC

RESOURCE LIBRARY
ACTIVITY : 1 HR 40 MINS

Biomagnification and Bioaccumulation

Students read about bioaccumulation and biomagnification, then position themselves as part of the ocean food web. They use evidence to justify an argument about whether plastic pollution harms humans. Finally, they draw a food web for a specific marine ecosystem that illustrates biomagnification verbally and visually.

GRADES

6 - 8

SUBJECTS

Biology, Ecology, Health, Chemistry, Conservation

CONTENTS

9 PDFs

OVERVIEW

Students read about bioaccumulation and biomagnification, then position themselves as part of the ocean food web. They use evidence to justify an argument about whether plastic pollution harms humans. Finally, they draw a food web for a specific marine ecosystem that illustrates biomagnification verbally and visually.

For the complete activity with media resources, visit:
http://www.nationalgeographic.org/activity/biomagnification-and-bioaccumulation/

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DIRECTIONS

***Plastics: From Pollution to Solutions* unit driving question**: *How can humans solve our plastic problem in the ocean?*

***Plastic in the Plankton, Plastic on your Plate* lesson driving question**: *How do plastics affect ocean organisms and ecosystems?*

1. Guide students to see themselves as being part of the marine food web.

- Ask: *Who likes to eat seafood? What is your favorite kind of seafood?*
    - After hearing several responses, it may be useful to remind students that seafood includes not only fish and fish products such as tuna salad, fish sticks, or sushi, but also shellfish like lobster, crab, shrimp, clams, oysters, and mussels.
- Inform students that if they eat any type of seafood, they are part of the ocean food web.
- Define *food web* and add it to your class unit word wall. Instruct publishing teams to add this entry to their magazine glossary list, including the definition and an example sentence.
- Ask: *What trophic level would you consider yourselves to be?* (apex predator)
- Remind students that although eating seafood provides essential nutrients such as protein and omega-3 fatty acids, doing so can also come with some negative consequences.
- Ask: *What could be some negative consequences from eating seafood?*
    - Possible response: If the fish have eaten microplastics, we could also be eating those microplastics.
- Tell students that in this activity, they will make an argument, based on evidence, about whether microplastics have any effect on humans. Explain that this is a question that scientists are currently researching.
- Introduce students to the issue and how scientists are approaching the question with the video *Are Microplastics in Our Water Becoming a Macroproblem?* (2:51)

2. Read an article summarizing the state of research on plastics in the food web.

- Project the article *We Know Plastic Is Harming Marine Life. What About Us?*
    - Preview the article's structure to generate interest and predictions about its content; then read it aloud to the class.
    - Because there is a significant amount of high-level vocabulary in this article, it is best facilitated through a whole-class read-aloud with opportunities to pause for questions and clarification.

    - It begins by summarizing information students already know about plastic impacts, but continues to add information and lingering questions about toxic chemicals working their way up the food chain.

- To conclude the article, ask students to discuss one or two of the following questions with a partner, then invite several groups to share their responses with the class:

    - *In your opinion, what is the most serious health impact of plastics on animals addressed in this article? Why?*
    - *In your opinion, what is the most serious health impact of plastics on people brought up in this article? Why?*
    - *Which of the solutions proposed in the article seem most effective? Why?*

3. Guide students to confront both the evidence and the uncertainties about the impacts of ocean microplastics on humans.

- Label four large sections of your whiteboard with these titles:

    - Plastics in the food chain are harming humans now.
    - Plastics in the food chain are not harming humans now, but may in the future.
    - Plastics in the food chain do not harm humans, now or in the future.
    - I still need more information to make a decision about this.

- Explain that each of these statements is a claim. Tell students that in science, a claim is like an opinion, but one that must be supported by facts and evidence.
- Organize students into their publishing teams and distribute several sticky notes to each student.

    - Ask students to consider all of the evidence they have learned so far and decide which of these four claims they most agree with.
    - Prompt students to write two to three pieces of evidence on their sticky notes that support their claim.
    - Call students up by publishing team to place their sticky notes on the section of the board with the claim that most closely matches their current understanding. Students should be called up with their publishing teams, but should place their sticky notes individually.

- Observe and discuss any patterns in the distribution of sticky notes.

- Beginning with the first claim, ask a student who chose this statement to defend their claim, citing evidence to support their position.
- Ask for other students who agree with this student to add further supporting evidence.
- Then, ask for a volunteer who disagrees with this first claim. Ask which claim they chose and on what evidence their claim is based.
- Continue in this fashion until all four claims have been addressed. For the last claim, ask students what additional information they would need to make a decision, and what questions they have.
- Finally, ask if this discussion has caused any students to change their opinion about which claim is best supported by the evidence. Give students an opportunity to move their sticky note and explain why they changed it.

- Remind students that scientists also disagree about this topic, and it is an active area of research where new information is being learned all the time.
- Tell students that there are two more concepts they should understand to grapple with this issue: *bioaccumulation* and *biomagnification*. These concepts will also help them complete the *Food Web Infographic* element of their final project.

4. Introduce the concepts of bioaccumulation and biomagnification.

- Ask students to review the *Biomagnification and Bioaccumulation* infographic with the goal of defining both words.
- After reviewing the inforgraphic, invite students to help define *bioaccumulation* and *biomagnification* and add the words to your class unit word wall.
- Prompt publishing teams to add these entries to their magazine glossary list.

    - Introduce and encourage alternate forms of these words, such as *bioaccumulate* and *biomagnify*.

- To reinforce the difference between these two similar-sounding concepts, display the simplified *bioaccumulation and biomagnification infographic* so that all students can see it clearly. Ask: *Based on this infographic, what is the difference between bioaccumulation and biomagnification?*

    - Bioaccumulation takes place in a single organism over the span of its life, resulting in a higher concentration in older individuals.
    - Biomagnification takes place as chemicals transfer from lower trophic levels to higher trophic levels within a food web, resulting in a higher concentration in apex predators.

- Elaborate by telling students that some of the toxic chemicals found in microplastics form chemical bonds with certain body parts, such as fatty tissues and organs. Therefore, when the body excretes wastes, these chemicals often stay behind and continue accumulating instead of being flushed out with other wastes.
- Add that ingestion is not the only way microplastics can enter our bodies. In fact, some microplastic fibers from synthetic clothing, carpets, and furniture are small enough to float in the air, where we can breathe them in.

5. Develop the concept of a marine ecosystem as a particular habitat within the ocean.

- Refer to the *Final Project Checklist and Rubric* to remind students that their final project will contain a *Food Web Infographic* explaining the process of biomagnification. Remind students that, just like their *Ocean Plastics Movement Model*, the *Food Web Infographic* will require drafting and revision.
- Explain that, just like plastic is not a single material but a whole family of materials, the ocean is not a single habitat, but consists of a variety of different ecosystems.
    - Define *ecosystem* and add it to your class unit word wall.
    - Tell students to add this entry to their magazine glossary list, including the definition and an example sentence.
- Emphasize that an ecosystem consists of both living and nonliving things. The class has spent a lot of time discussing living things, or organisms, in the ocean.
- Ask: *What are examples of nonliving parts of ocean ecosystems?*
    - Possible responses:
        - water
        - salt
        - rocks
        - sand
        - light and sound energy
        - macroplastics and microplastics
        - other types of pollutants and litter

6. Guide teams through the development of an ecosystem-specific food web to model biomagnification.

- Assign each publishing team one of the following specific marine ecosystems (more than one team likely will be assigned to each ecosystem):

- arctic
- kelp forest
- mangrove
- sandy shore

- Distribute one *Food Web Organizer* and one copy of each group's assigned *Food Web Infographic* to each team.

  - *Food Web Infographic: Arctic*
  - *Food Web Infographic: Kelp Forest*
  - *Food Web Infographic: Mangrove*
  - *Food Web Infographic: Sandy Shore*

- Guide teams through the following process (also see Tips):

  - Ask students to look at the ecosystem presented on their *Food Web Infographic* and use the *Food Web Organizer* to classify each organism in their ecosystem according to their perceived trophic level.

    - Each ecosystem should have only one apex predator.
    - Some organisms may fit in more than one trophic level. For example, sea urchins and oysters can be considered both primary consumers and decomposers.
    - Circulate around the room while students are working and correct any major misconceptions using the answer keys provided.

      - *Food Web Infographic: Arctic Answer Key*
      - *Food Web Infographic: Kelp Forest Answer Key*
      - *Food Web Infographic: Mangrove Answer Key*
      - *Food Web Infographic: Sandy Shore Answer Key*

    - As teams work, you can inform them that they will have more time to work on their *Food Web Infographics* in the next activity, *Magazine Design Workshop II*, so they do not necessarily need to finish the infographics by the end of this activity.

  - Have each group select a color to represent photosynthesis, the flow of energy from the sun to primary producers. Tell them to include this color in their *Food Web Infographic* legend, and then to draw arrows using that color from the sun to the producers.

    - Use *this image of producers in a coral reef* as an example of correct arrow placement and direction.

- Next, have students select a color to represent herbivory, the flow of energy from primary producers to primary consumers. Tell them to include this color in their *Food Web Infographic* legend, and then to draw arrows using that color from primary producers to primary consumers.

    - Use *this image of primary consumers in a coral reef* as an example of correct arrow placement.
    - Emphasize to students that the head of the arrow shows the direction that matter and energy travel through an ecosystem, which is also the direction that plastic particles accumulate through a food web. Many students initially draw the arrows pointing from predator to prey, based on the misunderstanding that arrows represent hunting behavior.

- Repeat the same process for the flow of energy from primary consumers to secondary and tertiary consumers. For the purposes of this infographic, secondary and tertiary consumers will be considered part of the intermediate consumers trophic level (between primary consumers and apex predators).

    - Use *this image of secondary and tertiary consumers in a coral reef* as an example to show correct arrow placement.
    - Note that there are multiple "correct" ways to draw these arrows, since many marine organisms are opportunistic feeders that will attempt to prey on whatever vulnerable organisms they encounter. Tell students that the aim is to show the overall flow of matter and energy, not to draw every possible arrow, which would create a cluttered image.

- Repeat the same process for the apex predator.

    - Use *this image of an apex predator in a coral reef* as an example of correct arrow placement.

- Finally, repeat the same process for decomposers.

    - Use *this image of decomposers in a coral reef* as an example of correct arrow placement.
    - Remind students that, for the purposes of this activity, any small, bottom-dwelling invertebrates can be considered decomposers, and that some organisms in the ocean are both decomposers and consumers.

    - Since every living thing ultimately dies, every organism should have an arrow leading to a decomposer.

- Finally, have students choose a color to represent microplastics. Tell them to include this color in the legend, and then draw dots inside each organism representing ingested microplastic particles. This allows them to demonstrate their understanding of biomagnification.
- Ask: *How many dots should you draw inside each organism?*
    - Student's responses should demonstrate the following concepts:
        - Producers do not consume plastics, so they should have none.
        - Primary consumers should have a few dots.
        - Secondary and tertiary consumers should have more dots.
        - Apex predators should have the most dots.
        - Decomposers will have some dots as well, but since they do not consume prey whole, their concentration should be lower than the apex predator's.

- In conclusion, have students summarize biomagnification and its effects on their *Food Web Organizer*.

Tip

- **Step 3:** Working with students on supporting a claim using evidence connected through reasoning is an important skill emphasized in the Next Generation Science Standards (NGSS). Read more about the relationship between using evidence to support claims in *this article* from Ambitious Science Teaching. For even more information about how to implement and reinforce the Claim-Evidence-Reasoning framework in your science classroom, read this *blog post by Model Teaching*.

- **Step 6:** The point of the *Food Web Organizer* is not to be absolutely correct about every organism's trophic level, but rather to divide up the organisms in the ecosystem in a reasonable way. For example, the smaller an organism is, the lower its trophic level should be, and vice versa. Organisms on the sea floor can reasonably be classified as decomposers unless there is a compelling reason to believe otherwise. Encourage students to work efficiently and make justifiable decisions as a team.

Informal Assessment

Food Web Infographics completed by students provide insights into their current understanding of the cycling of matter through ecosystems, which they should demonstrate in both words and pictures; these documents should be stored in their project folders. Students' participation in the discussion about the impact of microplastics on human health demonstrates their current ability to make claims and support them with evidence.

Extending the Learning

Biomagnification and Bioaccumulation Game: This interactive, kinesthetic activity helps students review organisms in each trophic level of the food web and experience firsthand how biomagnification and bioaccumulation function to cycle plastics in an ecosystem.

OBJECTIVES

Subjects & Disciplines

Biology

- Ecology
- Health

- Chemistry
- Conservation

Learning Objectives

Students will:

- Create an argument about whether they think this plastic pollution is capable of causing harm to humans, and justify their argument with evidence.
- Identify producers, consumers, and decomposers in a variety of different marine ecosystems.
- Illustrate the process of biomagnification within a food web, showing the cycling of plastics and toxic chemicals between organisms.

Teaching Approach

- Project-based learning

Teaching Methods

- Discussions
- Multimedia instruction
- Simulations and games

Skills Summary

This activity targets the following skills:

- Science and Engineering Practices
  - Constructing explanations (for science) and designing solutions (for engineering)
  - Developing and using models
  - Engaging in argument from evidence
  - Obtaining, evaluating, and communicating information

National Standards, Principles, and Practices

NATIONAL GEOGRAPHY STANDARDS

• **Standard 8:**
The characteristics and spatial distribution of ecosystems and biomes on Earth's surface

NEXT GENERATION SCIENCE STANDARDS

• **Crosscutting Concept 2:**
Cause and effect: Mechanism and prediction
• **LS2.B Cycles of Matter and Energy Transfer in Ecosystems:**
Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem. Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms

in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem.

• **MS-LS2-3:**

Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.

• **Science and Engineering Practice 7:**

Engaging in argument from evidence

Preparation

What You'll Need

MATERIALS YOU PROVIDE

- Chart paper
- Colored markers
- Sticky notes

REQUIRED TECHNOLOGY

- Internet Access: Required
- Tech Setup: 1 computer per classroom, Printer, Projector, Speakers

PHYSICAL SPACE

- Classroom

SETUP

Prior to teaching this activity, set up four pieces of chart paper with the following titles and hang them in visible locations around the room:

- Plastics in the food chain are harming humans now.
- Plastics in the food chain are not harming humans now, but may in the future.
- Plastics in the food chain do not harm humans, now or in the future.
- I still need more information to make a decision about this.

When printing the *Food Web Infographics* (one set per team), keep them organized in a folder or with a paper clip (not stapled) so students can view them all together when spread out on a table.

GROUPING

- Large-group instruction
- Small-group learning
- Small-group work

BACKGROUND & VOCABULARY

Background Information

Do microplastics in the ocean food web affect humans? The short answer is, it's too soon to tell. We know we are consuming some amount of microplastics (and even tinier nanoplastics), but we don't know how they are affecting us, or indeed if they are affecting us at all. However, studies show that microplastics are part of the marine food web, and that the amount of microplastics in the oceans is increasing. Possibly the most concerning aspect of this problem comes not from the plastics themselves, but from their ability to ferry additives and other contaminants into our bodies: chemicals including polychlorinated biphenyls (PCBs), endocrine disruptors, flame retardants, and more. The precautionary principle suggests that we should pursue this line of inquiry until we arrive at satisfactory answers.

In spite of these uncertainties, the principles of bioaccumulation and biomagnification are well-established in toxicology. Perhaps the best-known example of this is with the pesticide DDT. Developed in the 1940s, DDT was sprayed widely throughout the mid-20th century to control harmful insects such as mosquitoes and elm bark beetles. Soon, scientists such as Rachel Carson noticed that birds that preyed upon these insects were also suffering as a result. Most dramatically, the eggshells of bald eagle eggs became thinner as a result of DDT's interaction with calcium, ultimately leading the EPA to ban the pesticide in 1972.

While the health effects of PCBs and DDT are well-established, the effects of other chemicals such as phthalates and endocrine disruptors are the subject of contentious debate. As with microplastics and nanoplastics, more research is required.

Prior Knowledge

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Recommended Prior Activities

- Autopsy of an Albatross
- Follow the Friendly Floatees
- Magazine Design Workshop I
- Plastics Aplenty
- The Life Cycle of Plastics

Vocabulary

Term	Part of Speech	Definition
bioaccumulation	*noun*	process by which chemicals are absorbed by an organism, either from exposure to a substance with the chemical or by consumption of food containing the chemical.
biomagnification	*noun*	process in which the concentration of a substance increases as it passes up the food chain.
ecosystem	*noun*	community and interactions of living and nonliving things in an area.
food web	*noun*	all related food chains in an ecosystem. Also called a food cycle.
ingest	*verb*	to take material, such as food or medicine, into a body.
pollutant	*noun*	chemical or other substance that harms a natural resource.