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ACTIVITY : 1 HR 40 MINS

The Life Cycle of Plastics

Students complete the physical journey of ocean plastics by studying microplastics. They imagine the so-called Great Pacific Garbage Patch, and then read an article to address evolving understandings. Students form a polymer chain to simulate the process of photodegradation. Finally, they perform skits about a plastic bottle making its way from mainland China to Midway Island.

GRADES

6 - 8

SUBJECTS

Chemistry, Earth Science, Oceanography, Storytelling

CONTENTS

3 PDFs

OVERVIEW

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For the complete activity with media resources, visit:
http://www.nationalgeographic.org/activity/life-cycle-plastics/

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DIRECTIONS

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

***Plastics, Plastics, Everywhere* lesson driving question:** *How do plastics get into and move around the ocean?*

1. Elicit students' prior knowledge about the Great Pacific Garbage Patch.

- Ask if any students have heard of the Great Pacific Garbage Patch. Some may recall that it was mentioned in their jigsaw resource and in videos used in this unit, but they have not yet learned a formal definition.
- Prompt students to sketch a picture in their notebooks of what they think the Great Pacific Garbage Patch looks like. They should include details such as what kind of garbage is found there, whether any animals live there, where the patch is located in the Pacific Ocean, and how large they think it is.
- Have students read *The Great Pacific Garbage Patch Isn't What You Think It Is* independently or with a partner to find out if their description was accurate.
- Encourage students to select the appropriate reading level (third, sixth, 11th, or 12th).
- Ask: *How does the reality of the Great Pacific Garbage Patch differ from the way you first imagined it?*
    - Possible responses:
        - It is mostly fishing nets and microplastics.
        - It covers an area larger than Texas.
        - The plastics come from at least 12 different countries.
        - It is not an island of trash.
- Instruct students to add a depiction of microplastics to their drawings of the Great Pacific Garbage Patch.

2. Address misconceptions about the idea that plastics do not break down.

- Define *microplastics* as pieces of plastic between 0.3 millimeters and five millimeters in diameter. Ask: *How big is a millimeter?*
    - Possible responses:

    - About the width of a grain of rice
    - About the width of a pencil lead
    - A millimeter ruler can be used to show this as well.

- Contrast microplastics with macroplastics, which are larger than 5 millimeters.
- Tell students that many people believe that plastics never break down. Clarify with the following information that this is a misconception:

    - It is true that plastics do not easily biodegrade. Biodegradation occurs when a material is digested by decomposers such as fungi, invertebrates, and bacteria. The end result of biodegradation is particles add to the nutrients of the soil and cycle back into the food chain.
    - There are very few plastics that can biodegrade in the right environmental conditions.

- Ask: *What kinds of factors might affect a plastic's ability to biodegrade?*

    - Possible responses:

        - *The type of plastic*
        - *Temperature*
        - *Humidity or moisture*
        - *Length of time*
        - *Kinds of organisms in the environment*

- Explain photodegradation: The vast majority of plastics do not biodegrade, but they can degrade by other processes. Sunlight, specifically UV radiation, plays a major role in degrading ocean plastics. This is known as photodegradation. Waves and salt also contribute to physical and chemical degradation of plastics.
- Prompt students to compare this process to biodegradation.

    - Possible response: *Unlike biodegradation, photodegradation does not result in harmless particles that can cycle back into the food chain. Rather, it results in smaller pieces of plastic, known as microplastics.*

3. Conduct a kinesthetic activity to demonstrate photodegradation on microplastics at the molecular level.

- Tell students that in order to visualize the photodegradation process, they will form a chain.
- Gather the 11 placards created in advance of this step (see Setup).

- Choose eight students to form a chain. Give each of these students the placard that reads *Macroplastic Polymer*. Have them hold up the placard so the class can read this.

    - Tell these students to link arms.
    - Remind the class that all plastics are made from polymers, which are long, chain-like molecules made from fossil fuels.
    - Explain that the chemical bonds between each link in the chain are very strong, which is what makes plastics useful, but also so hard to break down.
    - Add that when bacteria encounter plastic, because it is made by people, the bacteria usually do not have any way to digest the plastic like they would digest a natural substance such as wood or keratin, the natural polymer that makes up hair, fingernails, wool, feathers, and horns.

- Choose a student who is not part of the polymer chain to be the waves. Give them the placard that says *Waves* and tell this student to gently demonstrate the motion of waves breaking apart the students in the middle of the *Macroplastic Polymer* chain, creating two smaller chains.

    - Explain that waves can break apart macroplastics, but only slightly. Have the *Waves* student sit back down.

- Choose another student who is not part of the polymer chain to be salt. Give them the placard that says *Salt*.

    - Ask this student to gently demonstrate the chemical reaction of salt breaking apart the two *Macroplastic Polymer* chains into four smaller chains.
    - Have the *Salt* student sit back down.

- Finally, choose a final student who is not part of the polymer chain to be *UV Radiation (sunlight)*.

    - Give them the corresponding placard and have this student gently demonstrate the ability of sunlight to photodegrade macroplastics, breaking up the four chains into eight separate particles.
    - Have this student sit back down.

- At this point, all eight of the polymer students should be floating separately. Tell them to turn their placards around to the side that says *Microplastic Polymer*.

    - Emphasize that microplastics are small, sometimes even microscopic, but they are still synthetic polymers that are not small enough to be considered nutrients for the food chain. Nevertheless, many animals, large and small, eat microplastics.

- Thank all the volunteers and ask the students holding placards to return to their seats.
- Request that the class help you add the following words and their definitions to the word wall by drawing on what they have just learned in this activity:

    - microplastics
    - macroplastics
    - biodegradation
    - photodegradation

- Remind students that one of the important pieces of their magazine project is a glossary that contains terms like these.

4. Guide students through the process of telling the full story of the life cycle of plastic.

- Ask students for a brief summary of each of the first four activities in this unit.

    - Possible responses:

        - Autopsy of an Albatross activity: Plastic pollution can reach remote ocean habitats far away from human settlements.
        - Plastics Aplenty activity: Plastics are a large family of synthetic chemicals made from oil used in almost every aspect of modern life.
        - Follow the Friendly Floatees activity: Ocean surface currents tend to move in circular patterns affected by Earth's rotation.
        - So far, in this activity, we have learned that plastics do not biodegrade, but they do break down into microplastics.

- Students' next task will be to summarize the entire story of plastics, with each team performing a brief skit about one stage in its life cycle.
- Distribute the resource *Journey of a Plastic Bottle*, which features Story Points from the *Plastic: Sea to Source* StoryMap. Assign each team one of the Story Points on to six. Tell teams to read their Story Point and then create a brief skit in which team members act out what happens to plastics in their Story Point. Explain the roles they may choose:

    - Two narrators per group

    - One actor to play a piece of plastic (who also is responsible for explaining the data visualization that the group creates together)
    - One actor to play other roles, such as sunlight, landforms, or organisms

- Give students time to read their Story Point and decide which role each group member will play. Monitor each team's progress to ensure that the actors understand their roles and have practiced making appropriate movements.
- Beginning with Story Point One, present the skits of each team.

5. Conclude the story of the life cycle of plastics with questions that relate to the unit project.

- After the last skit, ask students if any stages of the life cycle of plastics are missing.
    - Possible responses:
        - There is not a Story Point about the production of plastics, which requires extracting oil and/or natural gas from the ground, refining it, and chemically combining molecules into polymers that can be molded into various forms.
        - There is also not a Story Point about the future of plastics, because they last a very long time in the environment and scientists still don't know exactly where they go or how they affect the animals that eat them.

- Summarize that students have just described the life cycle of plastics, from cradle (production) to grave (disposal).
- Ask: *Do you think life cycle is an appropriate term for this process, and if not, what would a better term be?*
    - Possible responses:
        - No, plastics are not alive.
        - No, the journey of plastics is rarely a cycle because 91 percent of plastics are never recycled.
        - No, because in a life cycle an organism's body is recycled by decomposers into particles that are used by other organisms to grow.
        - Students may have several ideas for a better term.

- Tell students to take out their *Final Project Checklist and Rubric*. In the next activity, they will work on their unit project. Tell them to mark the elements that they will focus on:
    - an introduction to what plastics are, how they are made, and the many ways in which they are used;

- an *Ocean Plastics Movement Model* showing how plastics reach the ocean and what happens to plastics in the ocean; and
- a glossary of related vocabulary used in the magazine

- In the remaining time, answer students' questions about the unit project and tell teams to assign roles for various parts of the unit project, which team members will work on during the following activity.

Modification

For students who benefit from having clear physical boundaries, inform them at the beginning of this lesson that it will involve an active and fun opportunity for acting out plastic processes. While they are encouraged to enjoy themselves by fully participating in the kinesthetic learning process, they should remember that they are still in a classroom space surrounded by peers.

Tip

- **Step One:** When reading *The Great Pacific Garbage Patch Isn't What You Think It Is*, decide on the best format for reading this article with your class. You may decide to project the internet-based article from your computer and read it as a whole class, to print out the article for individuals or pairs to read, or to provide computers for students to access the article online. If printing, be sure to select the appropriate reading level version.
- **Step Two:** Role-playing and kinesthetic learning are strategies that have great educational and entertainment value in a science classroom, but strong classroom management during these activities is essential. Read more from the *Association for Supervision and Curriculum Development* and *Stanford Teaching Commons.*
- **Step Four:** The Story Points focus on China, primarily because of China's large population and relatively underdeveloped solid waste management infrastructure. However, it is worth emphasizing to students that this story could take place anywhere across the globe. Also, depending on your students' sensitivity to cultural differences, you may want to remind students that they are not role-playing Chinese people, but rather that plastics, water, and natural forces exist everywhere on our planet.

Informal Assessment

Students' skits, their participation in discussions, and their developing ideas about their unit project provide insights into their current understanding about modeling the flow of matter (plastics) through systems (the hydrosphere).

Students' skits should include descriptions, both verbal and nonverbal, of the many forces that transport and degrade plastics.

Extending the Learning

To extend students' learning about marine debris, explore resources provided by the NOAA Marine Debris Program, especially those created for World Ocean Day in 2016. The Ocean Today *Trash Talk Special Feature* video (15:11) can be watched in its entirety or as shorter segments; consider showing the *Great Pacific Garbage Patch* (2:11) portion to help students understand how marine garbage patches are more like plastic soup than an island. Also check out the *Trash Talk Webinar* for educators.

OBJECTIVES

Subjects & Disciplines

- Chemistry

  Earth Science
  - Oceanography

  Storytelling

Learning Objectives

Students will:

- visualize and quantify the difference between macroplastics and microplastics;
- understand the difference between biodegradation and photodegradation; and
- synthesize information learned about plastic production, disposal, and movement into a cohesive storyline.

Teaching Approach

- Project-based learning

Teaching Methods

- Cooperative learning
- Reading
- Role playing

Skills Summary

This activity targets the following skills:

- 21st Century Student Outcomes
  - Learning and Innovation Skills
    - Communication and Collaboration
- 21st Century Themes
  - Environmental Literacy
- Critical Thinking Skills
  - Creating
- Science and Engineering Practices
  - Constructing explanations (for science) and designing solutions (for engineering)
  - 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 4:**
Systems and system models
• **LS2.C: Ecosystem Dynamics, Functioning, and Resilience:**

When the environment changes in ways that affect a place’s physical characteristics, temperature, or availability of resources, some organisms survive and reproduce, others move to new locations, yet others move into the transformed environment, and some die. (secondary to 3-LS4-4)

Preparation

What You'll Need

REQUIRED TECHNOLOGY

- Internet Access: Optional
- Tech Setup: 1 computer per classroom, 1 computer per pair, Projector

PHYSICAL SPACE

- Classroom

SETUP

In this activity, students physically act out processes that affect plastic movement and degradation. Therefore, ensure that you have a large, wide, and clearly visible area of the classroom cleared for skits.

Also, prepare in advance:

- eight placards with large text that says *Macroplastic Polymer* on one side and *Microplastic Polymer* on the opposite side;
- one placard with large text that says *Waves;*
- one placard with large text that says *Salt;* and
- one placard with large text that says *UV Radiation (sunlight).*

GROUPING

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

BACKGROUND & VOCABULARY

Background Information

The degradation of plastics by biological, physical, and chemical processes is a complex topic that requires significant background knowledge in organic chemistry. Different plastics with varying properties break down differently, depending on their environment. In addition to microplastics and macroplastics, some researchers have begun to characterize mesoplastics (in between micro and macro) and nanoplastics (smaller than micro). However, there is no universally agreed-upon technical definition of these terms.

The last several years have seen a significant movement toward developing and using biodegradable and plant-based plastics. While this is an encouraging trend, it is far from a silver bullet to the plastic pollution problem. Simply put, many of these supposedly biodegradable and/or compostable plastics do not actually biodegrade in the environment, because they require temperatures as high as 50°C(122 °F) to break down.

On the other hand, some scientists are researching organisms, including bacteria, fungi, and insects, that can digest certain forms of plastics. This research is promising, but also raises the specter of genetically engineered microbes being released into the environment to clean up plastics, with enormous potential for unintended consequences. Other researchers have proposed that microbes in the natural environment may already be evolving to digest plastics, but this hypothesis remains unproven.

Prior Knowledge

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Recommended Prior Activities

- Autopsy of an Albatross
- Follow the Friendly Floatees
- Plastics Aplenty

Vocabulary

Term	Part of Speech	Definition
biodegradation	*noun*	process of a material being broken down by decomposing organisms into harmless particles.
macroplastics	*noun*	pieces of plastic larger than 5 mm in size.
marine debris	*noun*	garbage, refuse, or other objects that enter the coastal or ocean environment.
microplastics	*noun*	piece of plastic between 0.3 and 5 millimeters in diameter.
photodegradation	*noun*	process by which a substance is broken down by exposure to light.