

Teacher/Facilitator Guide



WAVE OF PLASTIC

Meaningful Watershed Educational
Experience

LESSON TWO WHAT IS PLASTIC?

- How do we describe, quantify, and communicate about the issue of plastic waste?
- What are some of the consequences of the manufacture, use, and disposal of plastic?
- What happens to plastic over time?
- What are some of the alternatives to plastic?
- What properties of plastic influence our everyday choices to use plastic?
- How can we communicate our ideas, inform perspectives, and inspire action?

Unit Driving Question:

How do human choices regarding the consumption and disposal of plastics impact ecosystems and our communities and what actions can we take to minimize those impacts?

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Wave of Plastic MWEE Unit Next Generation Science Performance Expectations

Earth and Human Activity

- [MS-ESS3-4](#). Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems. Add evidence and clarification statements
- [MS-ESS3-3](#). Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

Lesson 2: What is Plastic? Performance Expectation

Matter and its Interactions

- [MS-PS1-3](#). Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.

Lesson Two Key Ideas

- Plastic is a synthetic, human-made material derived from natural resources (primarily “fossil fuels” like natural gas, oil, and petroleum).
- Plastic has many properties that make it a favored material for the manufacture of a wide variety of everyday items.
- Even though some of the ingredients to make the material for a plastic item may have been organic at one time, the manufacturing process changes the chemistry and structure so that the material becomes extremely difficult for decomposers to break apart. This means that items made from plastic may break *up* into smaller pieces but are not easily broken *down*. Thus, plastic remains and accumulates in the environment.
- There are many factors that influence the individual choices that people make for using plastic. We can survey our communities to understand these choices and inspire positive behavior change.

Lesson Two Overview

	Goal	Description	Activities
Part 1 Introduction	Building Understanding	Make sense of plastics as synthetic materials.	1. Read, Review, & Respond: Students will collect, organize, and synthesize information about the manufacture and properties of plastic.
Part 2 Investigation	Integrating Information and Ideas	Explore the properties of plastic that have positive and negative impacts on the environment and society.	2. Read, Review, & Respond: Students will read an article, “ <i>Breaking Down Trash</i> ,” to make sense of what happens to waste over time and will respond to questions in their Student Workbooks. 3. Activity: “Make Your Own Bio- Plastic.” Make plastics out of biodegradable substances. 4. Analyze, Share, & Reflect: <i>Updating Our Personal Waste Inventories</i>. Students will return

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			<p>to their personal waste inventory to explore what happens to their waste over time.</p> <p>5. Activity: “What Happens to Our Waste?” OPTIONAL Students investigate the degradability (including biodegradability) of a variety of waste materials over time.</p>
Part 3 Application	Applying What We Learned Through Informed Action	Design and administer a ‘plastic use’ survey for the school community.	6. Engaging Others: Students will design and administer a survey for the school community to understand, inform, and influence people’s choices regarding plastic use.
Part 4 Assessment	Demonstrating Our Understandings	Complete a constructed response using the <i>Claim, Evidence, Reasoning</i> model.	7. Construct an argument supported by evidence: Students describe what makes plastic a synthetic material, and how the properties of plastics impact society.



Part 1- Introduction: Building Understanding

Objectives:

- We will obtain, evaluate, and communicate information about the materials used to make plastics, how plastics are made, the changes that plastics undergo as they are used and discarded, and why the manufacture, use, and disposal of plastic can be problematic.

Supporting Questions:

- How do we describe, define, quantify, and communicate the issue of plastic waste?
- What are some of the consequences of the manufacture, use, and disposal of plastic?

1. Activity: Read, Review, & Respond

Students will:

- Collect, organize, and synthesize information about plastics as synthetic (man-made) materials that are derived from natural resources.
- Explore changes that plastics go through as they are made, used, and discarded.

Whole Group Discussion Questions:

- What are plastics?
- How are they made?
- How and why are they used?
- What happens to plastics over time?
- What are some of the positive and negative consequences for the manufacture, use, and disposal of plastic?

Materials & Resources

- **Lesson Two:** Student Workbook
- **Video:** “Plastics 101”
 - **Source:** National Geographic Society
 - **Description:** Once a completely natural product, much of today's plastic is man-made and largely dependent upon fossil fuels. From polymers to nurdles, learn how plastic is created and what we can do to slow the lasting repercussions this material will have on both our planet and our lives.
 - **Link:** <https://video.nationalgeographic.com/video/101-videos/00000163-6503-de85-a16b-679316cc0000>.
- **Infographic:** UMCES Plastic Watch Solomons Outdoor Sign #2
 - **Description:** How long does it take for plastics to break up into microplastics.
 - **Source:** UMCES Plastic Watch
 - **Link:** <https://www.umces.edu/PlasticWatch>

Part 2- Investigation: Integrating Information & Ideas

Objectives:

- We will gather and make sense of information to describe that everyday items that are made from plastic are synthetic materials made from natural resources and impact society
- We will investigate alternatives to plastic that may be used to manufacture everyday items.
- We will investigate how types of plastic polymers degrade over time

Supporting Questions:

- What happens to plastic over time?
- What are some of the alternatives to plastic?

2. Activity: Read, Review, & Respond

Read, Review, and Respond

Students will:

- Read and review resources to make sense of what happens to waste over time and will respond to questions in their Student Workbooks.

Whole Group Discussion Questions:

- *Review & discuss student responses to the questions in the Student Workbook as a whole group*

Materials & Resources

- **Article:** “*Breaking Down Trash.*”
 - **Source:** Wave of Plastic UMCES team
 - **Description:** What do we mean by ‘trash?’ What is biodegradability? Why does it matter?
- **Web-based Article:** “Measuring Biodegradability”
 - **Source:** Science Learning Hub, (New Zealand government-supported science learning site)
 - **Description:** In nature, different materials biodegrade at different rates. This article explores the rates and processes by which different materials biodegrade.
 - **Link:** <https://marinedebris.noaa.gov/discover-issue/types-and-sources>
- **Online Dictionary:** “Biodegradable”
 - **Source:** Merriam-Webster.com
 - **Description:** Students can explore the etymology and definition of biodegradable
 - **Link:** <https://www.merriam-webster.com/dictionary/biodegradable>
- **Video:** “What are microplastics?”
 - **Description:** Microplastics are small plastic pieces less than five millimeters long which can be harmful to our ocean and aquatic life.
 - **Source:** NOAA National Ocean Service
 - **Link:** <https://oceanservice.noaa.gov/facts/microplastics.html%5C>
- **Sample Infographic:** “Plastics in the Ocean”
 - **Description:** Example of the use a creative visual to convey a pollution related concept
 - **Source:** NOAA Marine Debris Program (Office of Response and Restoration)
 - **Link:** [https://marinedebris.noaa.gov/multimedia/infographics#prettyPhoto\[field_image_image\]/7/](https://marinedebris.noaa.gov/multimedia/infographics#prettyPhoto[field_image_image]/7/)

Part 2: Investigation: Integrating Information & Ideas

3. Activity: “Make Our Own Bio-Plastic”

Students will:

- Work in teams to make their own bio-plastic that can be molded into usable items. They will consider and discuss the impact that bio-plastics could have on society and the environment.

Whole Group Discussion Questions:

- *Review & discuss student responses to the questions in the Student Workbook as a whole group*

Materials & Resources

Recipe 1:

- *Plant based oils* (corn oil, and/or sesame oil, and/or vegetable oil)
- *Cornstarch* -1 tablespoon
- *Water* -1 tablespoon
- *Food coloring*
- *Measuring spoons*
- *Eyedroppers* (optional)
- *Wooden skewers or metal spoons* (to stir the bioplastic mixture)
- *Paper cup or small beaker*-1 per group (in which to heat and mix the bio-plastic)
- *Access to a microwave oven*

Recipe 2:

- *Glycerin/Glycerol* -1 teaspoon (Glycerin is used as a plasticizer in this application. It can be found at local drugstores and supermarkets.)
- *Cornstarch* -1 tablespoon
- *Water* -4 tablespoons
- *Vinegar* -1 teaspoon
- *Food coloring*
- *Measuring spoons*
- *Eyedroppers* (optional)
- *Wooden skewers or metal spoons* (to stir the bioplastic mixture)
- 1 paper cup or small beaker per group (in which to heat and mix the bio-plastic)
- *Access to a microwave oven*

Activity: Make Our Own Bio-Plastic

Description: “Bio-plastics” are types of plastic made from renewable, biological materials like starches, cellulose, oils or proteins. They generally contain little or no petroleum and therefore are usually biodegradable. When bio-plastics are exposed to the environment (sunlight, heat, water, microorganisms) they *breakdown* into natural compounds like carbon dioxide and water.

In this activity, students will work in teams to make their own bio-plastic that can be molded into usable items. They will consider and discuss the impact that bio-plastics could have on society and the environment.

Materials

□ Recipe 1:

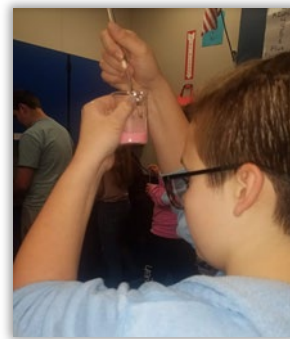
- *Plant based oils* (corn oil, sesame oil, and/or vegetable oil)
- *Cornstarch* -1 tablespoon
- *Water* -1 tablespoon
- *Food coloring*
- *Measuring spoons*
- *Eyedroppers* (optional)
- *Wooden skewers or metal spoons* (to stir the bioplastic mixture)
- *Paper cup or small beaker*-1 per group (in which to heat and mix the bio-plastic)
- Access to a *microwave oven*

□ Recipe 2:

- *Glycerin/Glycerol* -1 teaspoon
- *Cornstarch* -1 tablespoon
- *Water* -4 tablespoons
- *Vinegar* -1 teaspoon
- *Food coloring*
- *Measuring spoons*
- *Eyedroppers* (optional)
- *Wooden skewers or metal spoons* (to stir the bioplastic mixture)
- *1 paper cup or small beaker per group* (in which to heat and mix the bio-plastic)
- Access to a *microwave oven*

Procedures:

1. In a paper cup or beaker, mix all ingredients for Recipe 1 until combined.
2. Heat in a microwave oven for 20-25 seconds. Carefully remove the cup containing the mixture from the microwave and let it cool for a few minutes. While it is still warm, students can form the bioplastic mixture into a ball.
3. Encourage the students to try to mold the bioplastic into usable items (for example, cups, spoons, toys, etc.).
4. Repeat steps 1-3 for Bio-Plastic Recipe 2.
5. Allow the bioplastic to dry completely (this may take several hours).



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4. Activity: Analyze, Share, & Reflect: Updating Our Personal Waste Inventories

Students will:

- Return to their personal waste inventory and will complete a supplementary chart that focuses on the amount of time it takes for each item to degrade and how it degrades (for example, does it break apart into smaller pieces, etc.). Students should begin with making a prediction of how long they think it will take for each item to degrade before conducting research to determine the amount of time it will actually take.

Materials & Resources

- *Access to the internet* or other resources that identify the length of time certain waste items take to break down or break up.

Whole Group Discussion Questions:

- *Review & discuss student responses to the questions in the Student Workbook as a whole group*

5. Activity: “What Happens to Our Waste?” *OPTIONAL*

**Note that there is a separate student workbook for this activity*

Students will:

- Investigate the degradability (including biodegradability) of a variety of waste materials over time.

Materials & Resources

- *Clear plastic bins/trays* with lids
- *Water* collected from one or more natural sources*
- *Soil*
- *Scale or balance* (to measure potential changes in mass over time)
- *Windowsill* or similar access to sunlight.
- A variety of objects and materials to represent waste. *There should be objects made from organic materials as well as plastic. Students may choose items from the Personal Waste Inventory they created in Lesson One, Our World of Waste.*

Items may include:

- Notebook Paper, napkins, paper towels
- Glass bottle
- Plastic bottle
- Apple core, orange peel, banana peel
- Fishing line
- Food wrappers
- Plastic Materials made in the “Make Our Own Bio-Plastic” Activity*.

**Note: Samples from natural sources are necessary for there to be microorganisms present in the water to support biodegradation.*

Activity: “What Happens to Our Waste?”

**Note that this activity is optional and may extend beyond the time used to teach this lesson.*

**Note that there is a separate student workbook for this activity*

Description: In this activity, students will plan and carry out an investigation to make sense of how different materials degrade over time. They will work in teams to determine and articulate the goal of the investigation, predict outcomes, and plan a course of action that will provide the best evidence to support their conclusions.

Objectives:

1. *Ask Questions, Define the Phenomenon, Make Predictions:* Students define and describe the processes of degradation that we will investigate. Then they use what they understand about biodegradability to make predictions about the effects that independent variables (such as water, soil, material type) will have on the dependent variables (mass and other observable features) for a variety of waste items.
2. *Plan and Conduct an Investigation:* Students will develop a plan for collecting, recording, and analyzing data that will answer the investigation questions about the degradability of different materials. They will identify and justify appropriate variables and determine the methodologies for collecting data.
3. *Analyze and Interpret Data:* Students will use the data collected in their investigations as evidence to support claims about the effects of independent variables (such as water, soil, material type) on the dependent variables (mass and other observable features) for a variety of waste items.
4. *Construct, Communicate, Refine Explanations:* Students will synthesize evidence from their investigations and apply their understandings of biodegradability to draw conclusions about the degradation of different waste materials.

Procedures:

1. Students will begin by describing degradation and the importance of biodegradation (the key processes that we will be investigating). *(Note: responses will vary but students should focus on the ideas that many things degrade, but some merely break apart into smaller and smaller pieces while others break down completely through biodegradation. Biodegradation is important for regulating the amount of waste that accumulates in ecosystems)*

What is Biodegradability?

Different materials break down in different ways. Biodegradability is the ability of materials to be broken down by microorganisms like fungi or bacteria that digest the materials and break it down into simple, inorganic substances such as water, carbon dioxide, and methane. Natural materials such as plants, animals and products made from plants and animals (for example, natural fabrics like cotton, silk, and wool; untreated wood; and paper) are considered biodegradable.

2. Students will select waste items and, using what they’ve learned about biodegradability, make predictions about how they will degrade in given conditions over time.

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3. Students will plan, implement, and evaluate an investigation that will generate data to provide evidence to support each of their claims. In their design, students will consider aspects of the investigation process:
 - Students should consider why we will be looking at mass as a dependent variable in this investigation. Other dependent variables (e.g. color or structure) may also be discussed. A dependent variable is one that is being studied and measured as data points. *(Note: responses may vary, but as microorganisms digest portions of the material in the biodegradation process, they will be converting components of the materials into separate compounds such as water and carbon dioxide. Thus, the original mass of the item will be reduced as biodegradation occurs. Changes in color or structure (e.g. becoming more brittle) may also occur.*
 - Students should identify the independent variables in their models and make predictions regarding the impacts of those variables on the dependent variables. *(Note: for example, the water and soil might contain microorganisms that could be involved in biodegradation, sunlight could contribute to photodegradation and changes in color, the type of materials that make up the plastic waste would determine if it could be biodegraded, etc.)*

What is Photodegradation?

Photodegradation is the alteration and/or breaking down of materials by exposure to light (usually sunlight) and air. This is the only natural process which breaks down plastic. Plastic is made up of long polymer chains, tangled together, making the object strong. Components of sunlight cause the long polymer chains to react with oxygen from the air and break down into shorter chains. As more of the plastic molecules react and break down, there are fewer long chains holding the object together- it becomes brittle and breaks into smaller and smaller pieces.

4. Students then plan and implement their investigation. They should collect data over several weeks and even months if possible, recording their dependent variable at regular intervals (e.g. weekly).
5. Students should describe the results of the investigations by reporting the effects they observed.
6. Students will then make claims about the effects of independent variable (such as water, soil, material type) on the dependent variables (mass and other observable features) of the waste items they observed.
7. Finally, students will make broader conclusions about the degradation of different types of waste.

Part 3 – Application: Applying What We Learned Through Informed Action

Objectives:

- We will describe that everyday items that are made from plastic are synthetic materials that come from natural resources and impact society
- We will design and administer a survey to collect information about the preferences and choices of people in your school community regarding plastic use.
- We will share what we've learned in the lesson investigations and from the survey results.

Supporting Questions:

- What properties of plastic influence our everyday choices to use plastic?
- How can we communicate our ideas, inform perspectives, and inspire action?

5. Activity: Engaging Others

Students will:

- Review the UMCES Plastic Watch Community Survey and brainstorm information about personal plastic use that they could collect from the community.
- Design their own survey and administer it to the school community.
- The teacher/facilitator may decide the medium through which the surveys will be designed and administered. For example, surveys may be electronic, designed using an online program such as Survey Monkey or Google Forms, or created in a word document.
- Students may work individually, in groups, or as a whole class.
- Analyze the results, summarize them, and share with the community.
- The results should include a discussion of the sources of plastics and alternatives to plastic.

(Note: The teacher/facilitator and/or students may decide how to share the information with the community. For example, the information may be shared in a flyer, brochure, poster, or newsletter)

Whole Group Discussion Questions:

- Review & discuss student responses to the questions in the Student Workbook as a whole group

Materials & Resources

- **UMCES Plastic Watch Survey**

- **Link:**

- <https://www.umces.edu/PlasticWatch/survey>

(Note: Available on pages 12-13 of this guide as well as in a separate PDF)

- **OPTIONAL:** Access to online survey design program

- **OPTIONAL:** Posters, paper, markers, art supplies, etc. for creating flyers and posters to share the results.

The *PlasticWatch* Project – Community Survey*

In the PlasticWatch project, the University of Maryland Center for Environmental Science (UMCES) Chesapeake Biological Laboratory partnered with local restaurants in Maryland to offer alternatives to single-use plastic products, such as biodegradable straws or the option of having no straw at all!

This survey is designed to find out how much plastic people use, what they think about alternative, biodegradable products, and their opinions on plastic in the environment. We will use the information we collect to identify how to most effectively switch from plastic products, including straws, cups and take-out containers, to biodegradable alternatives.

*This version of the survey has been modified from its original version for use in the *Wave of Plastic Meaningful Watershed Educational Experience*.

1) How many plastic disposable straws do you use per week?

- None
- 1-3
- 4-7
- 8-10
- 10+

2) Are you willing to go without a straw in your drink?

- Yes
- No

3) How often do you recycle your plastic products and containers?

- Less than 25%
- 25-50%
- 50-75%
- 75-100%

4) Have you used a biodegradable paper straw or take-out container at a restaurant recently?

- Yes
- No

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5) How satisfied were you with the biodegradable product?

- Very dissatisfied
- Slightly dissatisfied
- Neither dissatisfied or satisfied
- Slightly satisfied
- Very satisfied

6) How long do you think it takes a plastic straw to break up?

- 1 year
- 4 years
- 45 years
- 200 years
- 2000 years

7) What are some of the ways that plastic ends up in the rivers and ocean? Select all that apply.

- From boats
- Winds blowing trash out of a garbage can
- Releasing a balloon outside
- Throwing a plastic wrapper out of a car window

8) What are microplastics?

- Recycled plastic
- Tiny pieces of plastic
- A biodegradable plastic

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Part 4- Assessment: Demonstrating Our Understandings

Objectives:

- Students will construct a convincing argument, supported with evidence, that supports or refutes claims for either explanations or solutions.
- Students describe a chain of reasoning that describes plastic as a synthetic material derived from natural resources that affects society in positive and negative ways.

Claim/Evidence/Reasoning Writing Rubric

	0	1	2	3
Claim – statement or conclusion that answers the original question/problem.	Does not make a claim.	Makes an inaccurate claim.	Makes an accurate but incomplete claim.	Makes an accurate and complete claim.
Evidence – scientific data that supports the claim. The data needs to be appropriate and sufficient to support the claim.	Does not provide evidence.	Only provides inappropriate evidence (Evidence that does not support the claim.).	Provides appropriate, but insufficient evidence to support claim. May include some inappropriate evidence.	Provides appropriate and sufficient evidence to support claim.
Reasoning - justification that links the claim and evidence and includes appropriate and sufficient scientific principles to defend the claim and evidence.	Does not provide reasoning	Only provides reasoning that does not link evidence to claim.	Repeats evidence and links it to some scientific principles, but not completely.	Provides accurate and complete reasoning that links evidence to claim. Includes appropriate and sufficient scientific principles.

Use the Claim, Evidence, Reasoning model.

Describe what makes plastic a synthetic material, and describe how the properties of synthetic plastics impact society