Science and Innovation
A Boeing/Teaching Channel Partnership

POLYMERS FOR THE PLANET
Teacher Handbook
Polymers for the Planet
Day 2: Characteristics and Properties of Polymers/Plastics

<table>
<thead>
<tr>
<th>Grade Level</th>
<th>Grade 5</th>
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<tbody>
<tr>
<td>Lesson Length</td>
<td>One 50-minute session (if possible, consider adding another day)</td>
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Lesson Overview

In this lesson, students make close observations of seven different types of household plastics. Students identify the characteristic and properties of the plastics through their observations. At the end of the lesson, students select one type of plastic to “mimic” in their design work. They identify specific criteria for their biopolymer based on their observations of the characteristics and properties of the model plastic.

Connecting to the Next Generation Science Standards

On Day 2, students make progress toward developing understanding across the following three dimensions:

- **Science and Engineering Practices**: Asking Questions and Defining Problems, Planning and Carrying Out Investigations
- **Crosscutting Concepts**: Influence of Science, Engineering, and Technology on Society and the Natural World, Patterns

In the following table, the specific components addressed in this lesson are underlined and italicized. The specific connections to classroom activity are stated.

<table>
<thead>
<tr>
<th>Performance Expectations</th>
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</thead>
<tbody>
<tr>
<td><strong>This lesson contributes toward building understanding of the following engineering performance expectations:</strong></td>
</tr>
<tr>
<td>3-5-ETS1-1. Define a simple design problem reflecting a need or a want <em>that includes specified criteria for success</em> and constraints on materials, time, or cost.</td>
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<tr>
<td><strong>This lesson contributes toward building understanding of the following physical science performance expectations:</strong></td>
</tr>
<tr>
<td>5-PS1-3. <em>Make observations</em> and measurements <em>to identify materials based on their properties.</em></td>
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</table>

Specific Connections to Classroom Activity

In this lesson, students observe common household plastics to identify the characteristics and properties of plastics. Through this activity, students identify the features of plastics that are important to society. Next, students select one type of plastic to mimic in their biopolymer design work. Using the characteristics and properties of the selected plastic, students develop a list of specified criteria for their design.
### Science and Engineering Practices

**Asking Questions and Defining Problems**
- Define a simple design problem that can be solved through the development of an object, tool, process, or system, and includes several criteria for success and constraints on materials, time, or cost.

**Planning and Carrying Out Investigations**
- Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution.

In this lesson, students continue to define the design problem for the module when they observe the properties and characteristics of existing plastics. Students identify the characteristics and properties of the type of plastic that they want to mimic in their design work. The observed characteristics and properties become a list of criteria for their design work.

### Disciplinary Core Ideas

**ETS1.A Defining and Delimiting Engineering Problems**
- Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account.

**PS1.A: Structure and Properties of Matter**
- Measurements of a variety of properties can be used to identify materials.

Prior to beginning their design work, students conduct research on existing plastics. They pay close attention to the characteristics and properties of existing plastics that make them useful to society. Students identify the characteristics and properties of the type of plastic that they want to mimic in their design work. The observed characteristics and properties become a list of criteria for their design work.

Students begin thinking about PS1.A as they identify properties and characteristics of existing plastics.

### Crosscutting Concepts

**Influence of Science, Engineering, and Technology on Society and the Natural World**
- Engineers improve existing technologies or develop new ones to increase their benefits, decrease known risks, and meet societal demands.

**Patterns**
- Similarities and differences in patterns can be used to sort, classify, communicate and analyze simple rates of change for natural phenomena and designed products.

Students observe existing plastics to try to make improvements on them. Students identify the characteristics and properties of existing plastics that make them useful to society so they can mimic the characteristics and properties in their design work.

Students observe the similarities and differences of seven different plastics.

### Middle School Extensions

If you are adapting this module to a middle school context, consider the following performance expectations:

- **MS-PS1-1:** Develop models to describe the atomic composition of simple molecules and extended structures.
- **MS-PS1-3:** Gather and makes sense of information to describe that synthetic materials come from natural resources and impact society.

To meet the performance expectations, students would need to examine the atomic composition of materials used to make plastics (crude oil, natural gas, salt, and so forth) and the atomic composition of the plastics. Students should consider the ways by which the natural resources combined to make synthetic materials. Students should also consider how the use of natural resources and creation of plastics impacts society.
Basic Teacher Preparation

This lesson introduces students to the seven types of commonly found plastics, along with each plastic’s proliferation and use in our world. Several different examples of the plastics from all seven categories must be available so students have several options to choose from during their exploration. Students can be asked to bring additional plastic samples from home. Reference cards based on the provided document links should be made ahead of time.

Review the Talk Science Primer, to help you prepare to lead the class consensus discussions. Refer to the Polymers for the Planet Student Handbook ahead of time so you can address any questions students might have. All Day 2 documents can be found on pages 6–10 in the Polymers for the Planet Student Handbook. The documents used in this lesson are:

- Characteristics and Properties of Polymers/Plastics (pages 6–9)
- Small Group Design Work: Identifying Design Criteria (page 10)

Required Preparation

<table>
<thead>
<tr>
<th>Required Preparation</th>
<th>Links/Additional Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gather examples of all seven types of commonly used plastics to bring to class;</td>
<td>Refer to the Materials List for this lesson</td>
</tr>
<tr>
<td>encourage students to bring examples</td>
<td></td>
</tr>
<tr>
<td>Create seven informational reference cards, one for each type of plastic</td>
<td>Refer to the Suggested Teacher Resources at the end of this lesson</td>
</tr>
</tbody>
</table>

Materials List

<table>
<thead>
<tr>
<th>Item</th>
<th>Description/Additional Information</th>
<th>Quantity</th>
<th>Where to Locate/Buy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Various plastic examples</td>
<td>Be sure to have examples of all seven types of plastics commonly used in packaging</td>
<td>Numerous examples—enough variety for class use</td>
<td>Students and/or the teacher can bring samples from home</td>
</tr>
</tbody>
</table>
| Informational cards about the seven types of plastics | • PETE (soda and water bottles, mouthwash bottles, some shampoo bottles)  
  • HDPE (milk cartons, detergent bottles, yogurt tubs, grocery bags)  
  • V (plastic food packaging, squeezable bottles)  
  • LDPE (bread bags, frozen food bags, squeeze bottles)  
  • PP (ketchup bottles, some yogurt tubs)  
  • PS (meat trays, egg cartons, cups and plates)  
  • Other | One card for each table (seven cards total) | A visual reference to use while creating your own reference cards can be accessed here: [Image Link]  
You may use the resource cards from the Smart Plastics Guide and the Guide to Common Household Plastics or use the linked resources to develop your own.
Day 2: Characteristics and Properties of Our Biopolymers

Introduction (5 minutes)

Begin the lesson by referencing the DQB. Remind students that the Driving Question for the module is, *How do we design a biopolymer that is less harmful to the environment than plastic?* On Day 1, students made progress on answering the first question, *Why do we need a better plastic?* On Day 2, students think more deeply about the second question, *What characteristics or properties should our biopolymers have?*

Tell students that their goal today is to try to figure out what characteristics and properties make plastics useful to society. As engineers, the students need to know the specific characteristics and properties of plastics that make plastic useful to society so they can re-create these characteristics and properties in their biopolymers.

Investigation: Characteristics and Properties of Our Biopolymers (20 minutes)

On separate tables in the room, place samples for one of the seven types of plastics, resulting in seven “stations.” Each station should include a resource card noting background information about that type of plastic. You may use the resource cards from the Smart Plastics Guide and the Guide to Common Household Plastics, or use the resource links to develop your own.

Students should visit each station and make observations. Their goal is to make observations about the specific characteristics and properties of each type of plastic, and compare the different types of plastics. Later, they use this information to try to mimic the characteristics and properties of plastics in their biopolymer.

NGSS Key Moment

Lesson 2 accomplishes two important goals:

- First, students practice identifying the characteristics and properties of materials, an important step in 5-PS1-3.
- Second, students use their observations of the properties of materials to determine the criteria and constraints for their design problem, an important step in 3-5-ETS1-1.

Web Resources

Refer to the following visuals during preparation:

- One Word: Plastics! [Web Link]
- Guide to Common Household Plastics [Web Link]
- Smart Plastics Guide [Web Link]
- The Polymer Party [YouTube Link]
Students should look at the samples, read the key descriptions on the cards, and then record the characteristics and properties of each plastic on pages 6 through 9 in their Polymers for the Planet Student Handbook. Students should pay close attention to the similarities and differences among the plastics.

**Extension**

As an optional extension, have students test the tensile strength and elongation (see Days 6 and 7) of the plastics. This will help students determine the necessary tensile strength and elongation for their biopolymers.

**Whole Group Discussion: What Characteristics and Properties Should Our Biopolymers Have? (10 minutes)**

Lead the class in a consensus-building discussion. The goal of the discussion is to figure out the characteristics and properties that all plastics share, and the differences among the various types of plastics.

Start by asking students to share some of their observations about characteristics and properties that are common to all plastics. Next, have students share their observations about characteristics and properties that are unique to each type of plastic. Students should be searching for patterns of similarities and differences among the plastics. Keep track of the observations using a graphic organizer on the board.

Tell students that by making careful observations of the plastics, they began to identify some of the criteria for their biopolymers. Remind students that their biopolymers should mimic existing plastics so they can serve the same purposes for society. As a class, brainstorm some of the criteria for all of the biopolymers. These criteria should match the characteristics and properties that students reported for all plastics.

**Design Work: Identifying Design Criteria (10 minutes)**

Have students assemble into their small group design teams. Tell students that they are going to pick one of the household plastics as a model plastic to mimic with their biopolymer. Have the small group select their plastic and record it on page 10 in their Polymers for the Planet Student Handbook. Next, have students develop a list of criteria for their biopolymer. Tell students that their criteria should match their observations about the characteristics and properties of their model plastic.

**NGSS Key Moment**

Determining the similarities and differences among various types of plastics is an example of an activity in which students practice finding patterns, one of the crosscutting concepts!

**Extension**

As an optional extension, have students test the tensile strength and elongation (see Days 6 and 7) of the plastics. This will help students determine the necessary tensile strength and elongation for their biopolymers.
Returning to the Driving Question Board (5 minutes)

Reference the lesson question on the DQB, *What characteristics or properties should our biopolymers have?* Ask students if they think they made progress in answering the questions. Tell students to record their progress on sticky notes. When students are finished, they should read their sticky notes out loud to the class and post them to the DQB.

Extension

After discussing the plastics, share *The Polymer Party* (video) that provides more information about polymers. You may also choose to share the *BrainPop: Plastics* (video) and the *Big Question: Can We Make Plastics Sustainable?* (video) from the University of Minnesota.

Assessment

Several opportunities for formative assessment exist in this lesson:

- Polymers for the Planet Student Handbook entries can be used to monitor student progress during the module.
- Use student observations (pages 6–9) to assess student progress on key science and engineering practices and crosscutting concepts.
- Focus specifically on student work identifying design criteria (page 10) as an assessment of disciplinary core ideas for this lesson.

Use the identified assessment opportunities to monitor student progress on disciplinary core ideas, science and engineering practices, and crosscutting concepts. Provide appropriate supports or extensions when necessary.

Reference Appendix B for suggestions for meeting the needs of all learners.

Community Connections

The plastics used in the investigation could be from local organizations or commonly used products in the local community. When students select a plastic to mimic, they may want to select a plastic that is particularly important to the local community.
## Suggested Teacher Resources

<table>
<thead>
<tr>
<th>Resource</th>
<th>Link</th>
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<tbody>
<tr>
<td>Meeting the Needs of All Learners</td>
<td>Polymers for the Planet Teacher Handbook, Appendix B</td>
</tr>
<tr>
<td>Polymers for the Planet Student Handbook</td>
<td>[Resource Link]</td>
</tr>
<tr>
<td>One Word: Plastics (visual reference)</td>
<td>[Web Link]</td>
</tr>
<tr>
<td>Smart Plastics Guide</td>
<td>[Web Link]</td>
</tr>
<tr>
<td>A Guide to Common Household Plastics</td>
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<td>Big Question: Can We Make Plastics Sustainable?</td>
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<tr>
<td>Talk Science Primer</td>
<td>[Web Link]</td>
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