NATIONAL PEER REVIEWED

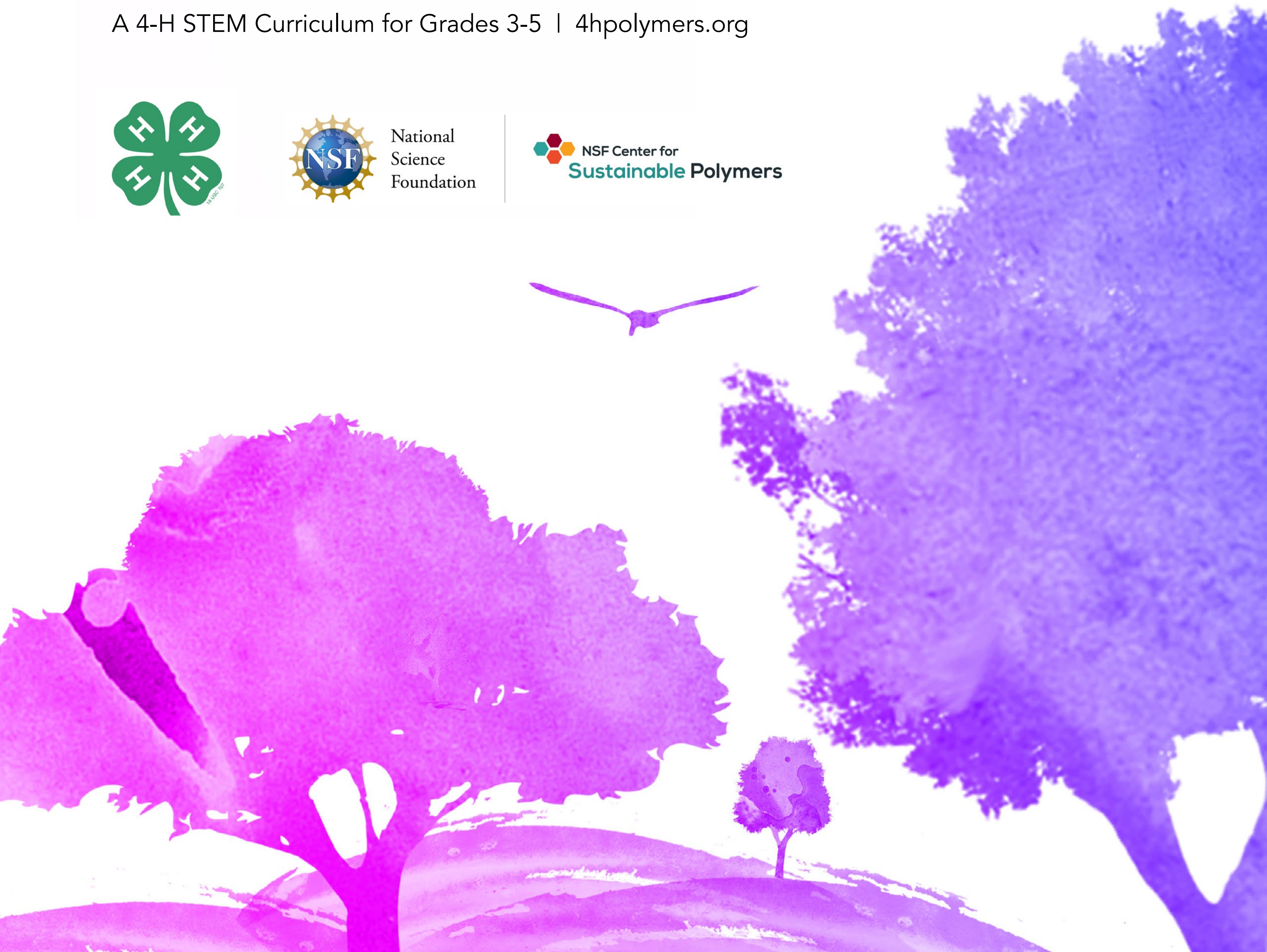
GRADES 3-5

Sustainable Polymers

Plastics of the Future for a Green, Clean World

A 4-H STEM Curriculum for Grades 3-5 | 4hpolymers.org

National Science Foundation | NSF Center for Sustainable Polymers



NATIONAL PEER REVIEWED

FRONT MATTER

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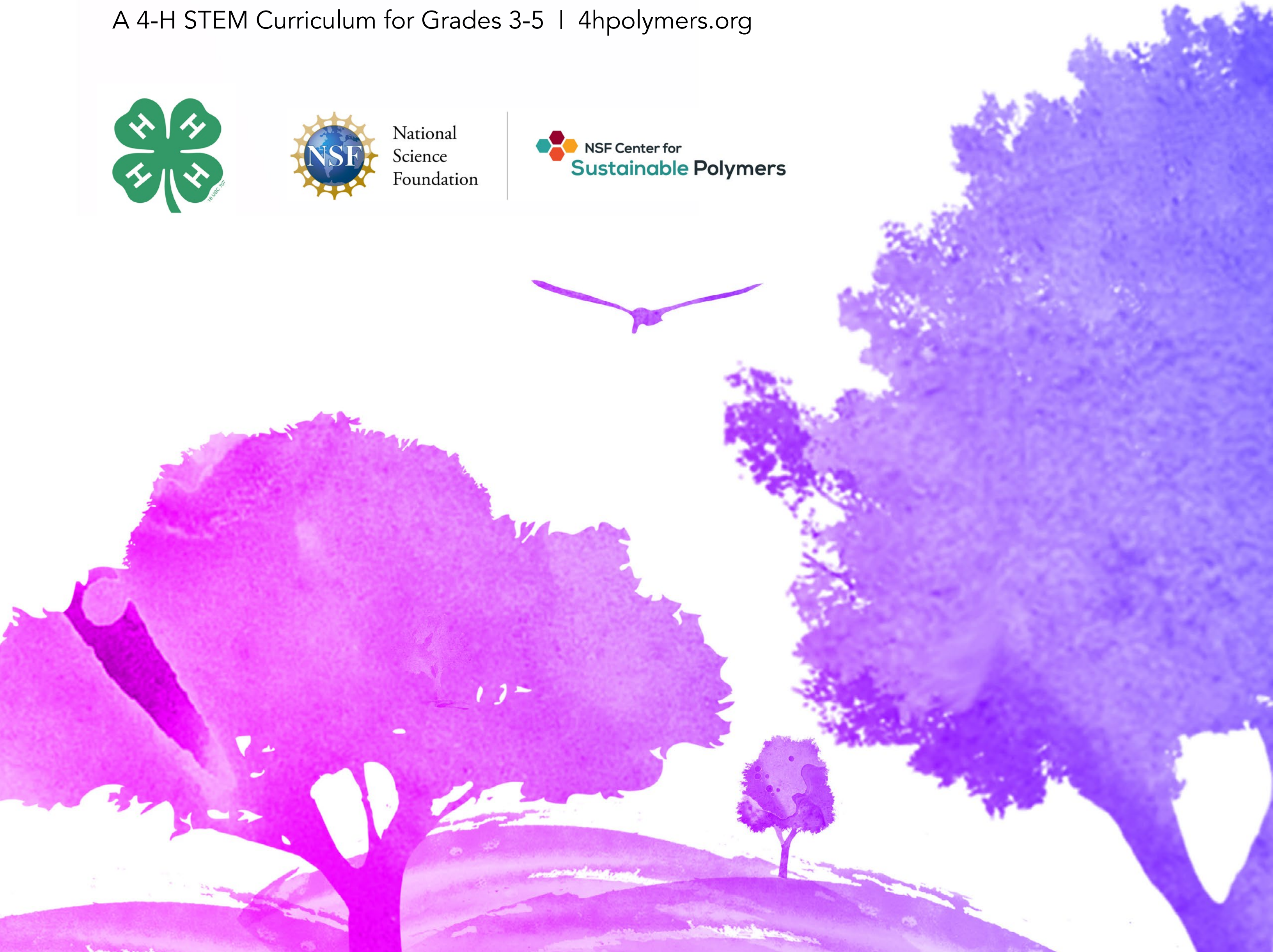

4-H Polymer Science Curriculum for

Grades 3-5

4hpolymers.org

The themes of these modules touch on the prevalence and impact of plastics in everyday life. Plastics are versatile materials that come in different shapes, sizes, and exhibit different material properties. Scientists and engineers are working on new ways to create, use, and recycle plastics, so we can use plastics for their many advantages and lessen their effects on our environment.

Each module will include "Tips for Facilitators" and the Science and Engineering Practices, as well as opportunities to use "I Wonder" Boards. In addition, these modules incorporate the SciGirls Strategies for gender equitable STEM learning. We encourage instructors to collect feedback throughout this module and submit via this evaluation form: **4hpolymers.org/evaluation**.

National Science Foundation

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Tips and Callouts

Facilitator Tips

These tips provide strategies and helpful suggestions for facilitators.

"I Wonder" Boards

These boards should be used to track children's questions and ideas during the lesson for further investigation. This tool promotes experiential learning by youth while encouraging curiosity and discovery. Basic "I Wonder" Boards have "I Wonder..." written at the top of a large sheet or white board.

Science and Engineering Practices

The Next Generation Science Standards (NGSS) identifies eight practices of science and engineering that are essential for all students to learn. Using these practices, youth make sense of phenomena and use these skills to investigate the world and design and build systems.

SciGirls Strategies

Based on educational research, the SciGirls Strategies are used to target and engage girls in STEM learning, but have also been proven to work with all learners, including underrepresented youth. See the SciGirls Strategies handout at the back of the module for a more detailed explanation.

Front Matter

Front Matter
Primary Authors: Jennifer McCambridge and Steven Worker

Introduction

Sustainable Polymers: Plastics of the Future for a Green, Clean World is an inquiry-based science curriculum in which youth discover and practice the skills used by scientists and engineers to learn about materials and their properties. Special attention is paid to plastic, a material that is prevalent in our world, and the concepts of sustainability; reduce, reuse, refuse and recycle; and the work of scientists and engineers around sustainable polymers. The curriculum is designed to build foundational skills of science and engineering: observation, asking questions and defining problems, planning and carrying out investigations, and communicating. The curriculum contains six learning modules intended for delivery in out-of-school time facilitated by an educator (trained volunteers or program staff). Modules also include "Science At Home" activities that may be completed by parents/other adults and children at home.

Curriculum Target Audience

Youth in grades 3-5 (8 to 12 year olds)

Developed by

A partnership between the NSF Center for Sustainable Polymers, University of Minnesota Extension, University of California Agriculture and Natural Resources, Cornell University Cooperative Extension, and *SciGirls*. This work is supported by the National Science Foundation (NSF) under the NSF Center for Sustainable Polymers CHE-1901635.

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RECOMMENDED CITATION

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INDIVIDUAL MODULE CITATIONS

McCambridge, J., & Worker, S. (2020). Front Matter. In A. Stevenson, J. McCambridge, & A. Mondl (Eds.). *Sustainable polymers: Plastics of the future for a green, clean world. A 4-H STEM curriculum for Grades 3-5.* NSF Center for Sustainable Polymers. University of Minnesota. https://www.4hpolymers.org/

Stevenson, A. (2020). Be a Scientist. In A. Stevenson, J. McCambridge, & A. Mondl (Eds.). *Sustainable polymers: Plastics of the future for a green, clean world. A 4-H STEM curriculum for Grades 3-5.* NSF Center for Sustainable Polymers. University of Minnesota. https://www.4hpolymers.org/

Stevenson, A., Mondl, A., & Strei, K. (2020). Materials Matter. In A. Stevenson, J. McCambridge, & A. Mondl (Eds.). *Sustainable polymers: Plastics of the future for a green, clean world. A 4-H STEM curriculum for Grades 3-5.* NSF Center for Sustainable Polymers. University of Minnesota. https://www.4hpolymers.org/

INDIVIDUAL MODULE CITATIONS (CONTINUED)

Bautista, J., Worker, S., Simpson, E., Panero, A., Breneisen, A., Bain, V., & Smith, M. (2020). Plastics in Your World. In A. Stevenson, J. McCambridge, & A. Mondl (Eds.). *Sustainable polymers: Plastics of the future for a green, clean world. A 4-H STEM curriculum for Grades 3-5.* NSF Center for Sustainable Polymers. University of Minnesota. https://www.4hpolymers.org/

Gullikson, T., Simpson, E., Panero, A., Bautista, J., Worker, S., & Smith, M. (2020). Plastics in Our World. In A. Stevenson, J. McCambridge, & A. Mondl (Eds.). *Sustainable polymers: Plastics of the future for a green, clean world. A 4-H STEM curriculum for Grades 3-5.* NSF Center for Sustainable Polymers. University of Minnesota. https://www.4hpolymers.org/

McCambridge, J. (2020). Buy, Sell, Create. In A. Stevenson, J. McCambridge, & A. Mondl (Eds.). *Sustainable polymers: Plastics of the future for a green, clean world. A 4-H STEM curriculum for Grades 3-5.* NSF Center for Sustainable Polymers. University of Minnesota. https://www.4hpolymers.org/

Keaney, A., & Worker, S. (2020). Service Learning. In A. Stevenson, J. McCambridge, & A. Mondl (Eds.). *Sustainable polymers: Plastics of the future for a green, clean world. A 4-H STEM curriculum for Grades 3-5.* NSF Center for Sustainable Polymers. University of Minnesota. https://www.4hpolymers.org/

LEARNING OBJECTIVES SUMMARY

In this set of six modules, youth explore the role of scientists and engineers in everyday life. As they work through the modules, youth discover and practice the skills used by scientists and engineers to learn about materials and their properties. Special attention is paid to plastic, a material that is prevalent in our world. Youth learn about the different types of plastics and their uses, as well as the positive and negative effects plastic (and its pollution) can have on humans, animals, and environment. To help protect the environment, youth explore issues of sustainability, such as renewable and non-renewable resources, strategies to reduce waste, and how to positively impact their communities through a service learning project.

MODULE SUMMARIES

1. **Be a Scientist**
   Youth explore materials and their properties and discover the skills used by scientists and engineers. Youth become slime scientists and toy engineers as they create and test slime materials. By using what they discover, youth create their own improved slime to meet their specifications.

2. **Materials Matter**
   Youth explore different types of materials, and are introduced to the terms monomer, polymer and molecule. They explore how the long chains of molecules that make up polymers and plastics affect the function of an object. Youth conduct a test to see how heat affects different types of plastics. They engage in a brief challenge and determine the advantages and disadvantages of various types of materials for a given task.

3. **Plastics in Your World**
   Plastic and plastic products are abundant in our world. In this module, youth learn about the different types of plastic and their uses. Using their senses, youth categorize plastics based on the U.S. 1-7 numbering system.

4. **Plastics in Our World**
   After learning about the uses of plastics in our everyday lives, youth work in teams to discover and evaluate disposal options for plastics such as recycling, landfill, reuse, refuse, repurpose, and industrial composting. Youth design solutions to lessen the controversial impacts plastic use has on the environment.

5. **Buy, Sell, Build**
   Youth discover more about renewable and nonrenewable resources through a game, in which they exchange resource cards at the marketplace in order to create plastic items. As resources are depleted or replenished, youth discover strategies to sustain building when supplies are limited.

6. **Service Learning**
   Participating in a service learning project is an opportunity for youth to apply science knowledge and/or skills to a real-world situation. Youth identify a need or problem in relation to polymers and plastics and create a plan to address that need or problem to complete the service activity.

CONTENT SUMMARY — THE IMPACTS OF PLASTIC

The theme of these modules touches on the prevalence and impact of plastics in everyday life. Plastics are versatile materials that come in different shapes, sizes, and exhibit different material properties. Plastics can be strong and rigid (such as safety helmets and the exterior of automobiles) or soft and flexible (such as those used in shoe cushioning or plastics bags). It's easy to find examples of plastics in everyday life and we all encounter plastic items at multiple points each day. There are many advantages to using plastic as they can be lightweight alternatives that can save on fuel and energy.

Along with the many advantages of using plastics, there are disadvantages to their use. Plastics that end up littered in the environment can take hundreds or thousands of years to degrade. It is estimated that 4.8 million metric tons of plastics end up in our oceans each year. One of the best ways to dispose of plastics is through a recycling program. Plastics that are recycled can be reprocessed into the same item or converted into a different item. However, not all plastic makes its way to the recycling bin. Only about 10% of all plastic is recycled - the rest is either incinerated, put into a landfill, or ends up as pollution in the environment.

Scientists and engineers are working on new ways to create, use, and recycle plastics so we can use plastics for their many advantages and lessen their effects on our environment. Some plastics are now designed to biodegrade without polluting the environment and others are created using renewable resources to lessen the dependence on traditional, oil-based plastics. The video, Plastic 101, by National Geographic provides a short background on how plastics and bioplastics are designed and manufactured: https://youtu.be/ggh0Ptk3VGE

LIFE SKILLS AND POSITIVE YOUTH DEVELOPMENT

Positive youth development builds on young people's strengths and assets. Youth development involves an intentional process that promotes positive outcomes for young people by providing opportunities, choices, caring relationships, and the support necessary for youth to fully participate in families and communities. High quality programming not only provides valuable benefits in knowledge, skills, and interests, but encourages leadership development, life skills development, and civic development. Through participation in science and engineering education, youth should have opportunities to strengthen their competence, confidence, connection, character, caring/empathy, and contribute to their community.

Practices to support positive youth development:

- Establishing a safe environment and building relationships. All youth need a caring, supportive relationship in their lives. Educators provide this by showing interest in, actively listening to, and fostering the assets of youth.
- Provide youth leadership opportunities. Creating opportunities for youth to develop skills and confidence for leadership and self-discipline is important for youth development.
- Provide community involvement experiences. Service forges bonds between youth and the community, and doing something valued by others raises feelings of self-worth and competence.

EXPERIENTIAL LEARNING CYCLE AND GUIDED INQUIRY

The curriculum is designed around the teaching methods of inquiry and experiential learning. Experiential learning is a cyclical process where learners have opportunities to construct meaning through engaging experiences. The cycle includes multiple phases including a concrete hands-on experience; a reflection phase where youth share, process, and generalize from the experience; and application of learning in new and authentic situations to deepen their understanding.

In a learning environment that promotes inquiry-based learning, youth build understanding through active exploration and questioning. The key to inquiry is that youth seek answers to questions rather than being given answers. This requires those who lead activities to facilitate the learning process and not simply disseminate knowledge. When activities are being led in an inquiry manner, youth actively question, observe and manipulate objects in the environment.

EXPERIENTIAL LEARNING MODEL

Source: Cooperative State Research, Education, and Extension Service (1996). Curriculum Development for Issues Programming - A Handbook for Extension Youth Development Professionals. Based on the work of Kolb, D. (1984). Experiential learning: Experience as the source of learning and development. New Jersey: Prentice-Hall.

EXPERIENTIAL LEARNING IN THE CURRICULUM

The curriculum outlines each activity around the experiential learning cycle:

- **Opening questions and prompts**: Before providing the materials for the experience, you should facilitate a group discussion to get youth thinking about what they know about the main learning objectives of the module.
- **Experiencing**: Procedures and instructions for a hands-on activity.
- **Sharing, Processing, Generalizing**: Help guide youth as they question, share, and compare their observations. Sample broad and open questions are included. Often, some of the sharing and processing takes place during "experiencing", however, it is vitally important to schedule time for group reflection after the activity. If necessary, use more targeted questions as prompts to get to particular points.
- **Concept and Term Discovery**: During this phase, it is important you ensure the primary learning objectives and concepts have been introduced or discovered by the youth.

Important factors to include in term discovery are: (a) concepts must be stated in the young people's own words; (b) you may then introduce the terminology used by scientists to refer to the concepts; and (c) you should lead a brief conversation on the importance of the concepts.

- **Application**: The true test of learners' understanding is when they can apply new knowledge and skills to authentic situations. When engaging youth in inquiry-based learning, hands-on activities serve as vehicles for learning new concept knowledge and skills; however, it is the application of new knowledge or skills to independent, real-world situations that is the critical factor in the learning process. Thus, to complete the cycle of experiential learning it is important to intentionally provide youth specific opportunities for authentic applications. Each module includes examples for real-world application.

RECOMMENDED EDUCATOR PRACTICES

The educator is a facilitator of learning, responsible for helping youth make meaning of their experiences. Educators are not expected to be the "sage on the stage" but rather the "guide on the side." Facilitating an open discussion is crucial in helping learners make meaning of their experience. Questions allow us to access information, analyze data, and draw sound conclusions. Good questions help stimulate thinking and creativity. To this end, broad and open questions are ideal in promoting discussion and interaction. They do not have a single right answer. In contrast, focused, narrow, and closed-ended questions tend to be fact-based or solicit yes or no answers and do not promote discussion. Encouraging science talk has four purposes (elicitation, consolidation, data, and explanation) and may involve full group, small group, or partner discussions. For more about encouraging productive science talk, see Sarah Michael and Cathy O'Connor's Talk Science Primer at: https://inquiryproject.terc.edu/shared/pd/TalkScience_Primer.pdf

The curriculum emphasizes the use of embedded evaluation and formative strategies to assess learning which may occur in multiple places during the implementation of an activity. First, educators may assess youth understanding of the main concepts and their engagement with Next Generation Science Standards (NGSS) practices and concepts through the types of questions youth ask, moments of wonder or puzzlement, and being able to successfully complete the task. Second, when youth share their ideas and experiences, the educators can assess how well youth understood the primary learning objective through the activity. Additionally, during the sharing, processing, and generalizing phase, educators can ask more focused questions to assess youth understanding, particularly with regard to the concept and term discovery. Finally, the application phase provides another opportunity to assess youth learning. Educators may have youth share their application activity at subsequent sessions.

To conduct outcome assessment of the curriculum, educators may want to administer the Draw-a-Scientist Test (DAST) to assess youth perceptions of scientists before and then again after the curriculum. Research has shown that children develop a stereotypic image of a scientist at an early age. Exciting, hands-on, and educational programs — such as this curriculum — should help youth deconstruct these images and help them start to see themselves as someone who can do, uses, and may contribute to science.

CONNECTION TO THE "*SCIGIRLS* STRATEGIES"

These modules were designed to incorporate the SciGirls strategies for gender-equitable STEM learning. *SciGirls* is an Emmy award-winning PBS Kids television show, website, and educational outreach program that engages girls in science, technology, engineering, and math (STEM) learning. Using research, *SciGirls* outlines best practices in their "*SciGirls* Strategies." These strategies are used to target and engage girls in STEM learning but have also been proven to work with all learners, including underrepresented youth. In the individual modules, practices that correspond to one of the "*SciGirls* Strategies" will be identified.

The *SciGirls* strategies for gender-equitable STEM learning are:

1 Connect STEM experiences to lives of young people

2 Support youth as they investigate using STEM practices

3 Embrace struggle, overcome challenges, and increase self-confidence in STEM

4 Identify and challenge STEM stereotypes

5 Emphasize that STEM is collaborative, social, and community-oriented

6 Interact with and learn from diverse STEM role models

CONNECTIONS TO NEXT GENERATION SCIENCE STANDARDS (NGSS)

This collection of activity modules builds many of the science and engineering practices identified in the Next Generation Science Standards. Youth in grades 3-5 will work on their skills in the eight practices (in this collection, however, less focus is on using mathematical and computational thinking).

Science and Engineering Practices:

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematical and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Youth explore many different disciplinary core ideas defined by NGSS through these six modules. These core ideas span the physical sciences (PS), earth and space sciences (ESS), and engineering, technology, and the applications of science (ETS).

Disciplinary Core Ideas:

1. Natural Resources (ESS3.A)
    - Energy and fuels that humans use are derived from natural sources, and their use affects the environment in multiple ways. Some resources are renewable over time, and others are not.
2. Human Impacts on Earth Systems (ESS3.C)
    - Human activities in agriculture, industry, and everyday life have had major effects on the land, vegetation, streams, ocean, air, and even outer space. But individuals and communities are doing things to help protect Earth's resources and environments.
3. Defining and Delimiting Engineering Problems (ETS1.A)
    - 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.
4. Developing Possible Solutions (ETS1.B)
    - Research on a problem should be carried out before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions.
    - At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs.
    - Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved.
5. Optimizing the Design Solution (ETS1.C)
    - Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints.

These modules also feature a number of crosscutting concepts. These concepts connect different areas of content by providing related connections and tools.

Crosscutting Concepts:

1. Cause and Effect
    - Cause and effect relationships are routinely identified and used to explain change.
2. Interdependence of Science, Engineering, and Technology
    - Knowledge of relevant scientific concepts and research findings is important in engineering.
    - People encounter questions about the natural world every day
3. Influence of Engineering, Technology, and Science on Society and the Natural World
    - People's needs and wants change over time, as do their demands for new and improved technologies.
    - Engineers improve existing technologies or develop new ones to increase their benefits, decrease known risks, and meet societal demands.

Together, the practices, core ideas, and crosscutting concepts covered through these modules mirror a number of performance expectations for children in grades 3-5, such as:

- Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment (4-ESS3-1).
- Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans (4-ESS3-2).
- Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment (5-ESS3-1).
- Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost (3-5-ETS1-1).
- Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem (3-5-ETS1-2).
- Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved (3-5-ETS1-3).

Grade 3-5 Glossary

This glossary is intended as content/background information for the facilitator.

- **Atom**: The basic unit of a chemical element; the smallest component of an element
- **Bacteria**: Microscopic living organisms that help with decomposition
- **Biodegradable**: A substance or object that can be decomposed by bacteria or other living organisms
- **Bioplastic**: Polymers often made from starch-containing plants, such as corn and potatoes. Many of these bioplastics are compostable
- **Criteria**: A standard by which something can be judged or decided
- **Degrade**: Matter breaks down into smaller parts by a chemical process
- **Engineer**: A person who uses creativity and a systematic approach to solving problems in ways that make peoples' lives easier and better
- **Function**: The purpose of an object or what it is used for
- **Indirect service**: Service that benefits the community or environment as a whole
- **Industrial Compost**: A site where organic waste products go through a multi-step process converting items into usable soil
- **Landfill**: A site where waste from the community is taken. Clay or soil is used to cover the waste to isolate it from reaching water systems.
- **Litter**: Waste items not properly disposed of in recycling, compost or trash receptacles; are instead left on the ground or in lakes/rivers/ponds
- **Matter**: Anything that takes up space is called matter (air, water, rocks, and even people are examples of matter). Matter can exist in one of three main states:solid, liquid, or gas.
- **Molecule**: The smallest unit of a substance that has all the properties of that substance; made up of two or more atoms
- **Monomer**: A part or single unit ('mono' means one and 'mer' means unit)
- **Natural polymers**: A type of polymer that comes from nature
- **Non-renewable resource**: A material made from resources that are only available in limited quantities and take a long time to be replenished (i.e. millions of years)
- **Petroleum**: Oil extracted from the earth that can be used for fuel or made into plastic

- **Plastic**: A human-made material made from polymers that can be molded into different shapes while soft, and eventually made firm or slightly flexible, usually made from petroleum or oil (traditional) but new plastics can be made from renewable resources like plants, such as corn, or algae (bio-based plastic)
- **Pollution**: Contamination by waste, chemicals, or other harmful substances to an environment
- **Polymer**: Large molecules made of long, repeating chains of smaller molecules called monomers. Each repeating unit is the "monomer," so polymer=many repeating units
- **Properties**: Characteristics that can be observed or measured; properties include size, shape, density, texture, hardness, color, odor, and other ways something looks or feels
- **Recycle**: To collect and process materials that would otherwise be thrown away as trash and turn them into new products
- **Refuse**: To say no to purchasing or using specific products with plastics, often single use plastics
- **Renewable resource**: A material made from naturally occurring resources that can be replenished, often within one person's lifetime
- **Reduce**: To limit the amount of plastic used in daily life
- **Repurpose**: To use an object for a new purpose other than it was originally intended
- **Reuse**: To use an object again for the same purpose it was originally intended
- **RIC-resin identification code**: A number used to identify plastic based on its composition. In the US, there are 7 resin identification codes which are usually placed within the "recycling symbol" of arrows forming a triangle.
- **Scientist**: A person who studies, specializes in, or investigates a field of science and does scientific work
- **Service Learning**: Connecting concept learning with needs of the community and responding with action
- **Single use**: To use a plastic item once and dispose after intended use
- **Starch**: An odorless and tasteless white substance made from plants
- **Sustainable**: Able to be maintained or run continuously
- **Synthetic Polymer**: A type of polymer made up of chemical compounds discovered by scientists; "human-made" rather than occurring in nature
- **Synthetic**: A material made by chemical means, especially to imitate a natural product.

The SciGirls Strategies

Proven Strategies for Engaging Girls in STEM

The **SciGirls** approach is rooted in research about how to engage girls in STEM. A quarter of a century of studies have converged on a set of common strategies that work, and they have become the framework for **SciGirls**. The original set of strategies, created in 2010, were updated in 2019 to reflect current research.

1 **Connect STEM experiences to girls' lives.**

(Boucheretal.,2017;Sammetetal.,2016;Bonner&Dornerich,2016;Ereteetal.,2016;Stewart-Gardineretal.,2013;Civil,2016;Verdinetal.,2016;Cervantes-Soon,2016).

Make STEM real and meaningful by engaging girls in activities that draw on their interests, knowledge, skills, culture, and lived experiences. This helps girls develop a STEM identity and increases their sense of belonging in STEM.

2 **Support girls as they investigate questions and solve problems using STEM practices.**

(Buckholz et al., 2014; Kim, 2016; Scott & White, 2013; Farland-Smith, 2016; Munley & Rossiter, 2013; Civil, 2016; Riedinger et al., 2016)

Engage girls in hands-on, inquiry-based STEM experiences that incorporate practices used by STEM professionals. Let girls take ownership of their own STEM learning and engage in meaningful STEM work to positively impact their identities and re-define how they see STEM.

3 **Empower girls to embrace struggle, overcome challenges, and increase self-confidence in STEM.**

(Blackwell et al., 2007; Dweck, 2000; Halpern et al., 2007; Kim et al., 2007; Mueller & Dweck, 1998)

Help girls focus on and value the process of learning by supporting their strategies for problem solving and letting them know their skills can improve through practice. Support girls to develop a growth mindset—the belief that intelligence can develop with effort and learning.

4 **Encourage girls to identify and challenge STEM stereotypes.**

(Allenetal.,2017;Carlietal.,2016;Cheryanetal,2015;Robnett,2016;Allenetal.,2017;Carloneetal.,2015;Sammetetal.,2016,Scottetal.,2014;Tanetal.,2013;Dasguptaetal.,2014;Verdin et al., 2016; Civil, 2016; Boucher et al., 2017)

Support girls in pushing against existing stereotypes and the need to conform to gender roles. Helping girls make connections between their unique cultural and social backgrounds and STEM disciplines will negate potential stereotype barriers.

5 **Emphasize that STEM is collaborative, social, and community-oriented.**

(Capobiancoetal.,2015;Diekmanetal.,2015;Leaper,2015;Riedingeretal.,2016;Robnett,2013;Parker&Rennie,2002;Scantlebury&Baker,2007;Werner&Denner,2009;Cakiretal.,2017; Sammet et al., 2016; Boucher et al., 2017; Clark et al., 2016; Leaper, 2015)

Highlight the social nature of STEM to increase interest and motivation and change the stereotypical perception that STEM jobs require people to work alone. Girls benefit from a supportive environment that offers opportunities to build relationships and form a collective identity.

6 **Provide opportunities for girls to interact with and learn from diverse STEM role models.**

(Kochetal.,2015;Leaper,2015;Adamsetal.,2014;Jethwanietal.,2017;Kessels,2014;O'Brienetal.,2016;Levineetal.,2015;Hughesetal.,2013;Cheryanetal.,2015;Weisgram&Diekman,2017)

Introduce girls to diverse women role models from varied STEM career pathways to help girls see potential futures and develop resilient STEM identities. Positive role models can increase girls' interests in, positive attitudes toward, and identification with STEM.

Supply/Material List Grades 3-5

**Please determine quantities based on the number of students

Supplies	Module 1 Be a Slime Scientist	Module 2 Materials Matter	Module 3 Plastics in Your World	Module 4 Plastics in Our World	Module 5 Buy, Sell, Build	Module 6 Service Learning
Drawing Paper	1 sheet per youth					
Scratch Paper			1 per student			
Writing/ Drawing Supplies (Pencils, pens, markers, crayons)	3-4 items per person	1 per student (pencils & pens)	1 per student	1 per student	1-2 per student	1-2 per student
Flip Chart	2 sheets	1 sheet	2 sheets			1 sheet per group
Masking Tape	1 roll					2 rolls
Scissors			1 pair	5-10 pair		
Random Objects Glass, plastic, wood, fabric (4 -5 bags)	1 assorted bag per group					
Technology equipment	X					X
20 Mule Team Borax	1 box					

Supplies	Module 1 Be a Slime Scientist	Module 2 Materials Matter	Module 3 Plastics in Your World	Module 4 Plastics in Our World	Module 5 Buy, Sell, Build	Module 6 Service Learning
Baking Soda	¼ tsp per person					
Non-Toxic White Glue	¼ cup glue per person					
Glue Variation (clear glue, colored glue, glue with glitter)	¼ cup per person					
Measuring Spoons (1 Tbls. & 1 tsp.)	1 set per group					
Plastic Cups	1 per pair	1 per pair				
Food Coloring	1 box per group				1 box per group	
Stirrers (spoons or craft sticks)	2 per youth					
Small Container with lids	1 per pair					
Small bowls/ plates	2 per youth					
Saline Solution (Contact lens solution)	1 bottle					
Water	¼ cup per recipe					

Supplies	Module 1 Be a Slime Scientist	Module 2 Materials Matter	Module 3 Plastics in Your World	Module 4 Plastics in Our World	Module 5 Buy, Sell, Build	Module 6 Service Learning
Beauty/ Texture options: (Acrylic paint, glitter, tiny beads, white foam shaving cream, scented lotion)	Assortment for your group					
Paper towels	2 rolls					
Sandwich bags	2 per youth				1 per student	
Hairdryer		1 per station (2-3)				
PLA Cups (compostable or GreenWare, #7)		1 per pair				
Polystyrene Cups (PS) (white styrofoam or clear plastic #6)		1 per student pair				
Bandanas		12-15				
Roll of Toliet Paper		1 roll				
Collected Assorted Plastic Objects (#1-7)		5 bags (see Module 2 for examples)	At least one of each plastic type per group		X	
Paper or Science Journal	1 per student	1 per student				

Supplies	Module 1 Be a Slime Scientist	Module 2 Materials Matter	Module 3 Plastics in Your World	Module 4 Plastics in Our World	Module 5 Buy, Sell, Build	Module 6 Service Learning
Small Stickers for Voting		3-4 per student				3-4 per student
Different Beverage Containers (glass, plastic, aluminum, and reusable water bottle)		1 set				
Paper Bags			1 per group	9 bags		
Plastic Bottles with Caps				1 per student		
Potting Soil				1 bag		
Herb or Flower Seedling				1 per student		
Cornstarch					1 Tablespoon per student	
Vegetable Oil					1 small bottle	
Microwave Oven					1	
Service Journal						1 per student
Supplies Specific to Service Plan (tools, equipment, or supplies)						X

Supplies	Module 1 Be a Slime Scientist	Module 2 Materials Matter	Module 3 Plastics in Your World	Module 4 Plastics in Our World	Module 5 Buy, Sell, Build	Module 6 Service Learning
Poster Board						X
Emergency Contact List	X	X	X	X	X	X
Community Partner Contact List						X
First Aid Kit	X	X	X	X	X	X
Camera						X
Snacks Supplies for Celebration						1-2 per student

Appendices To Be Printed

Module 1:

- ☐ Slime Recipe (Appendix B) - 1 per pair
- ☐ Slime Test Observation Sheet (Appendix C) - 1 per pair
- ☐ A Different Slime Recipe (Appendix D) - 1 per pair

Module 2:

- ☐ Cup wars data sheet (Appendix A) - 1 per group
- ☐ Polymer Cards (Appendix B) - 1 copy for the leader
- ☐ Four container description sheets (Appendix C) - 1 copy per group

Module 3:

- ☐ Observation Sheet (Appendix A) - 1 per group
- ☐ Sample Town Guide to Plastic Recycling (Appendix B) - 1 copy per pair
- ☐ Local recycling information

Module 4:

- ☐ Station Names - 1 copy for the leader (Appendix B)
- ☐ Item Cards (Appendix C) - 1 set single-sided, cut
- ☐ Recycling Center Reference Sheet (Appendix D) - 2 copies, cut in half
- ☐ Disposal Options Sheet (Appendix E) - 1 copy at each station A-D.
- ☐ Repurpose Idea Sheet (Appendix F) - print as many as needed

Module 5:

- ☐ Money cards for each group (Appendix A) - at least 2 pages/24 coins per group
- ☐ Supply cards (Appendix A) - at least 2-3 pages of corn/oil and 2 pages of chemical/factory per group
- ☐ Plastic item cards (Appendix A) (if not using real items) - at least 2-3 per group
- ☐ Recipe Cards (Appendix B) - 1 per group

Module 6:

- ☐ Facilitator Tip Sheet (Appendix A) - 1 for the leader
- ☐ Selecting A Project sheet (Appendix B) - 1 per group
- ☐ Project Planning Tool (Appendix C) - 1 per group
- ☐ Project Evaluation Form (Appendix D) - 1 per youth
- ☐ Service-Learning Model (Appendix E) - 1 for the leader

RESIN IDENTIFICATION CODE GUIDE

In the U.S., there are 7 resin identification codes which are usually placed within the "recycling symbol" of arrows forming a triangle. Use the chart below as a guide to know which types of plastics are recyclable and which types are not. Be sure to find out from your local municipality what materials are recyclable in your area.

SYMBOL	POLYMER NAME	PRODUCT EXAMPLES		
1 PETE	Polyethylene Terephthalate (PETE or PET)	• Soft drink bottles • Water bottles • Sports drink bottles • Salad dressing bottles • Vegetable oil bottles	• Peanut butter jars • Pickle jars • Jelly jars • Prepared food trays • Mouthwash bottles	
2 HDPE	High-density Polyethylene (HDPE)	• Milk jugs • Juice bottles • Yogurt tubs • Butter tubs • Cereal box liners	• Shampoo bottles • Motor oil bottles • Bleach/detergent bottles • Household cleaner bottles • Grocery bags	
3 V	Polyvinyl Chloride (PVC or V)	• Clear Food packaging • Wire/cable insulation • Pipes/fittings • Siding • Flooring	• Fencing • Window frames • Shower curtains • Lawn chairs • Children's toys	
4 LDPE	Low-density Polyethylene (LDPE)	• Dry cleaning bags • Bread bags • Frozen food bags • Squeezable bottles • Wash bottles	• Dispensing bottles • 6 pack rings • Various molded laboratory equipment	
5 PP	Polypropylene (PP)	• Ketchup bottles • Most yogurt tubs • Syrup bottles • Bottle caps • Straws	• Dishware • Medicine bottles • Some auto parts • Pails • Packing tape	
6 PS	Polystyrene (PS)	• Disposable plates • Disposable cutlery • Cafeteria trays • Meat trays • Egg cartons	• Carry out containers • Aspirin bottles • CD/video cases • Packaging peanuts • Other Styrofoam products	
7 OTHER	Other Plastics (OTHER or O)	• 3/5 gallon water jugs • Citrus juice bottles • Plastic lumber • Headlight lenses • Safety glasses • Gas containers	• Bullet proof materials • Acrylic, nylon, polycarbonate • Polylactic acid (a bioplastic) • Combinations of different plastics	

NATIONAL PEER REVIEWED

MODULE 1

GRADES 3-5

Sustainable Polymers

Plastics of the Future for a Green, Clean World

A 4-H STEM Curriculum for Grades 3-5 | 4hpolymers.org

National Science Foundation | NSF Center for Sustainable Polymers

4-H Polymer Science Curriculum for

Grades 3-5

4hpolymers.org

The themes of these modules touch on the prevalence and impact of plastics in everyday life. Plastics are versatile materials that come in different shapes, sizes, and exhibit different material properties. Scientists and engineers are working on new ways to create, use, and recycle plastics, so we can use plastics for their many advantages and lessen their effects on our environment.

Each module will include "Tips for Facilitators" and the Science and Engineering Practices, as well as opportunities to use "I Wonder" Boards. In addition, these modules incorporate the SciGirls Strategies for gender equitable STEM learning. We encourage instructors to collect feedback throughout this module and submit via this evaluation form: **4hpolymers.org/evaluation**.

National Science Foundation

NSF Center for Sustainable Polymers

Tips and Callouts

Facilitator Tips

These tips provide strategies and helpful suggestions for facilitators.

"I Wonder" Boards

These boards should be used to track children's questions and ideas during the lesson for further investigation. This tool promotes experiential learning by youth while encouraging curiosity and discovery. Basic "I Wonder" Boards have "I Wonder..." written at the top of a large sheet or white board.

Science and Engineering Practices

The Next Generation Science Standards (NGSS) identifies eight practices of science and engineering that are essential for all students to learn. Using these practices, youth make sense of phenomena and use these skills to investigate the world and design and build systems.

SciGirls Strategies

Based on educational research, the SciGirls Strategies are used to target and engage girls in STEM learning, but have also been proven to work with all learners, including underrepresented youth. See the SciGirls Strategies handout at the back of the module for a more detailed explanation.

Module 1

Be a Scientist!
Primary Authors: Anne Stevenson

If you are new to the 4-H polymer science curriculum and the youth you are working with have not participated in the "Be a 4-H Scientist! Materials for a Green, Clean World" curriculum for grades K-2, you may want to check out the K-2 curriculum at www.4hpolymers.org for background information or activities to support the learning objectives of this curriculum for grades 3-5

Introduction

MODULE SUMMARY

Youth will explore materials and their properties. Youth first consider what they think a scientist looks like and does, using the Draw-A-Scientist assessment. In activity A, youth use the practices of science and engineering as they sort and classify objects based on **properties**. **Properties** are characteristics that can be observed or measured; properties include size, shape, density, texture, hardness, color, and other ways something looks and feels. In activity B, youth will use criteria, standards by which something can be judged or decided, as they test slime materials and create their own improved slime.

Total lesson time needed for Module 1: 75-105 minutes not including set up time
Getting Ready: 35-60 minutes total

- Activity A: Draw a Scientist or Engineer (10-15 minutes)
- Activity B: What's my Property? (10-15 minutes)
- Activity C: Be a Slime Scientist (45-60 minutes)
- Reflection/Wrap Up (10-15 minutes)

Total estimated time for Module 1: **110-165** minutes, including set up time

Module Focus

LEARNING OBJECTIVES	• Youth will increase their interest in science and engineering • Youth will discover the work of a specific plastics or sustainability scientist/engineer • Youth will practice skills used by scientists and engineers
SCIENCE & ENGINEERING PRACTICES *Youth will engage in the following NGSS Practices:*	• Asking questions and defining problems • Obtaining, evaluating, and communicating information • Constructing explanations and designing solutions • Planning and carrying out investigations • Analyzing and interpreting data • Using mathematical and computational thinking
CONCEPTS & VOCABULARY	• **Criteria**: standards by which something can be judged or decided • **Engineer**: a person who uses creativity and a systematic approach to solving problems in ways that make peoples' lives easier and better • **Polymer**: large molecule made from chains of small repeating units. Each repeating unit is called a monomer • **Properties**: characteristics that can be observed or measured; properties include size, shape, density, texture, hardness, color, odor, and other ways something looks or feels • **Scientist**: a person who studies, specializes in, or investigates a field of science and does scientific work

Facilitator Preparation

ACTIVITY A

- ☐ Drawing paper - 1 sheet per youth
- ☐ Drawing supplies (pencils, pens, markers, crayons, etc)
- ☐ Flip chart paper - 2 sheets
- ☐ Marker (for facilitator) - 1
- ☐ Optional: Book: Ada Twist, Scientist (by Andrea Beaty) or Me, Jane (by Patrick McDonnell)

GETTING READY (5 MINUTES)

- Gather all supplies listed under Materials List

ACTIVITY B

- ☐ Bags of 15-20 random objects of various properties, (1 bag per small group) such as:
- Metal objects (e.g. paperclips, coins, keys)
- Glass objects (e.g. marbles, craft stones, small bottle)
- Plastic objects (e.g. containers, toys, hair clips)
- Wood (e.g. pencil, craft sticks)
- Fabric or soft objects (e.g. bandana, felt, cotton ball, toys)
- Other misc. objects

GETTING READY (10-15 MINUTES)

- Prepare bags of objects: 1 bag for each group of 3-4 youth. Each bag should contain 15-20 random objects which have a variety of properties, (metal, wood, glass, plastic, and fabric).
- Plan a method to divide youth into smaller groups of 3-4.

Facilitator Preparation (Continued)

MATERIALS - ACTIVITY B

Technology equipment to play Meet a Scientist video (i.e. laptop/tv, cables, internet connection, etc). Choose one at SciGirls:

3M Chemist: (4 min) http://www.scigirlsconnect.org/resources/chemist-bridgette-shannon/

Toy Engineer (2:06 min) http://www.scigirlsconnect.org/resources/toyologist-katie-broughton/

Robotic Scientist (2:37 min) http://www.scigirlsconnect.org/resources/robotic-soccer-scientist-manuela-veloso/

Scientist Story (Appendix A) if video/internet is not available -1 copy

MATERIALS - ACTIVITY C PART 1 (CONTINUED ON NEXT PAGE)

- ☐ 1 box borax powder, such as 20 Mule Team Borax (available in the laundry detergent aisle)
- ☐ Non-toxic white school glue (PVA) (washable)
- ☐ Baking Soda (you will need less than ½ cup for a group of 25)
- ☐ Contact lens (saline) solution-must indicate boric acid in the ingredients list (any cheap brand works fine) - 1-2 bottles depending on size of group
- ☐ Water
- ☐ Food coloring (optional)
- ☐ Stirrers (e.g. spoons or craft sticks)

GETTING READY (20-40 MINUTES)

Facilitator Tip
If your activity time is limited, you may choose to make slime ahead of the session, and have youth analyze the slime you have pre-made. Then focus your time for Activity B on youth creating their "different" slime from the provided ingredients.

Gather supplies and set up a work space for making slime.

- ☐ Make copies of Appendix B, C, & D - (B & C may be copied back-to-back).
- ☐ Consider how you will divide your group into pairs.
- ☐ In Part 1, youth will work in pairs to make slime according to directions, then analyze it. 5

Continued on next page

Facilitator Preparation (Continued)

- ☐ Measuring spoons -1 tablespoon and 1 teaspoon
- ☐ Small container with a lid OR small cups
- ☐ Plastic cups
- ☐ Slime Recipe Part 1 (Appendix B) - 1 copy per pair, OR print on chart paper or whiteboard for whole group
- ☐ Slime Test Observations Sheet, 1 copy for each pair (see Appendix C) or create for your group on chart paper
- ☐ Paper towels
- ☐ Sandwich bags (2 per youth for slime)
- ☐ Flip Chart paper - 1 sheet

PART 2

- ☐ Better Slime recipe template (Appendix D) - 1 per pair

For Activity C-Part 2, you will need to provide **several options** in addition to those listed above, which youth can choose from to make their new slime:

- ☐ **Glues**: washable, clear glue or colored clear glue, colored opaque glue, glue with glitter, or purchase PVA from a science supply store
- ☐ **PVA Activators (cross-linkers)**: Borax (use in crystal form, use in solution form), saline solution (contact lens solution--must list boric acid in its ingredients)
- ☐ **Beauty/Texture options**: food coloring, acrylic paint, glitter, tiny beads, white shaving cream (foam, not gel!), scented lotion

- ☐ In Part 2, youth may work in pairs or individually and create a "different slime," having choices as to what supplies to use. Set up work stations that allow for youth to easily access supplies and create their new slime recipes. Facilitators will need to determine which optional supplies you wish to provide.
- ☐ Ensure access to running water for cleanup

5 SciGirls

STEM is collaborative, social, and community-oriented

Background Information for the Facilitator

The things youth do in their daily lives are often similar to the work of **scientists** and **engineers**, although they may not realize it! Youth will often visualize these adults as wearing lab coats, building bridges, and using specialized tools. However, youth naturally use scientific and engineering concepts as they explore and change their world through design and play. The goal of this module is to help young people identify how their actions can reflect the work of scientists and engineers. The activities will help guide youth to a fuller understanding of what scientists and engineers do, the "practices" of science and engineering.

Science and Engineering Practices

Explain that scientists and engineers would do an experiment or redesign their plan more than once.

Additionally, the activities will help reinforce the idea that all of us use the skills associated with science and engineering in our everyday lives. In this module, we have highlighted most of the eight Science and Engineering Practices (Next Generation Science Standards) to support facilitators in introducing these Practices to youth and building this foundation for understanding. Create or utilize a poster of the 8 Practices of Science and Engineering. In each of the subsequent modules, youth will engage in two or three of the Practices. Facilitators are encouraged to continually guide youth to see themselves engaging in the Practices.

Background on Slime

The glue (partially hydrolyzed poly(vinyl acetate) or PVA) has long flexible chains of molecules in it; these chains are **polymers**.

Borax dissolved in water forms an ion called a borate ion. When the borax solution is added to the glue solution, the borate ions help link the long polymer molecules to each other so they cannot move and flow as easily (cross-linking of the polymers). When enough polymer molecules get connected together in the right way, the glue solution changes from a liquid to a rubbery substance.

- Water is an important ingredient in slime. Water helps the polymer molecules slide past each other so that the slime can flow. If you let the water evaporate, your slime will end up like a solid piece of plastic.
- See the Extension activities at the end of this module for an art project idea to add to this lesson which explains how to dry sheets of slime.

“I Wonder Board”
While the professional science and engineering communities often require specialized training and tools, anyone can learn to engage in similar processes and practices! Activities encourage “wondering” and emphasize how important it is for adults to model and encourage curiosity in youth. These “wonders” are often turned into questions that can be investigated or studied. Consider posting an “I Wonder” board (see Front Matter for full explanation) to help surface these “wonders” and perhaps provide inspiration for your group to dig deeper into their curiosities.

Activity A

Draw a Scientist or Engineer (10-15 minutes)

Youth will consider what they think a scientist or engineer looks like or does. It also helps the facilitator gain an understanding of the perceptions or misconceptions youth have about scientists and engineers. Few people are aware of all the different branches of science and engineering. This activity may be used as an assessment, by repeating the drawing after module six, to compare young people's perceptions of scientists and engineers after participating in all six modules. 4

OPENING QUESTIONS AND PROMPTS

Ask youth to close their eyes and imagine a scientist or an engineer at work.

PROCEDURE (EXPERIENCING)

1. Pass out paper and writing utensils/markers to every youth.
2. As youth are imagining (silently), a further prompt could be: "What do you know, or think you know, about scientists (or engineers)?"
3. Allow 1-2 minutes for youth to think in silence. On their sheet of paper, ask youth to sketch what they imagined and any ideas they have about what a scientist (or engineer) does or looks like when they are working. Allow youth to draw for 5 to 8 minutes.

4 SciGirls

Identify and challenge STEM stereotypes

SHARE/PROCESS/GENERALIZE:

After drawing, have youth share their pictures and ideas as you make a word web or a list. Keep this for future sessions so that youth can keep adding how their thinking is changing and expanding. These visuals will be a youth created definition of "scientist" and "engineer." Ideally youth can add to it independently at arrival or departure time.

- Ask youth to describe similarities and differences between what people drew.
- Explain that in our next activity, we will use a skill that both scientists and engineers use, which is using our senses to make observations.

Facilitator Tip
See Front Matter: Draw A Scientist Test, for further explanation.
Save these drawings for a later activity and for outcome assessment purposes.

Activity B

What's My Property?
(10-15 minutes)

Youth discover different properties as they sort and classify objects, building a foundation for understanding how the properties of materials and matter influence its purpose. Youth also meet a scientist 4 who is using chemistry to study and make materials, and hear about some of the challenges and rewards of being a scientist.

OPENING QUESTIONS AND PROMPTS

Facilitate a group discussion to get youth thinking about what they know about the main learning objectives of the module. You may ask the following prompts. There is overlap in some questions between modules so you may want to develop new broad, open-ended questions for your group, if needed.

- Describe some of the **properties** of objects around you.
- Explain how you think scientists use the term property.

Facilitator Tip
Youth may think of land, or something one "owns." Youth may also understand **property** to describe a characteristic of something, such as soft or hard. You can tie these definitions to each other because, in a sense, an object does "own" its property.

4 SciGirls
Identify and challenge STEM stereotypes

PROCEDURE (EXPERIENCING):

1. Divide youth into pairs. **5** Explain that partners will work together to find an object in the room that fits the description of a property, given by the facilitator. For example, for the property "soft," youth should find an example of an object that is soft. Additional examples could include: waterproof, brittle, strong, absorbent, clear, opaque, shiny, and rough. (If needed, you can brainstorm properties youth know, such as clear, shiny, transparent, bendy, etc. in the opening question.)

2. Play for approximately five minutes, and address any differences of opinion by asking further questions of the youth. You might invite several pairs of youth to explain their differing opinions to the whole group (e.g. "Your team thinks this cup is hard. What is your reasoning or evidence? Your group disagrees that this cup is hard; what evidence do you use to show it isn't hard?")

Facilitator Tip
You can add in the vocabulary word "**criteria**" at this point if the youth have not yet used the term. You might ask the youth "What makes a friend a great friend?" Explain that they have identified "criteria" for what makes a good friend and that "criteria" are standards by which something can be judged or decided. You can return to an example from this activity to highlight how criteria for a property can vary based on the uses of the object and needs of the user.

3. Continue to introduce or help define "properties" words as youth hunt for or explain what they found.

4. Explain to youth that their next challenge is to identify properties of different materials. This game is called "What's My Property?" Pairs can combine into small groups of 4 students.

    - Each group needs a bag of about 15 objects that includes different materials and has different properties.

5 SciGirls
STEM is collaborative, social, and community-oriented

- Ask each group to determine the person whose birthday is closest to today's date. This person will serve as the first "leader." The role of the "leader" will change with each round so that every youth has the opportunity to fill this role.
- The leader should think of one specific property (without saying aloud) and separate the objects into two piles: one pile of items that have the property and one pile of items that do not. The other youth should then figure out what the property might be.
- If group members suggest a property that the leader did not originally intend, the leader can respond, "That's a good one but not the one I'm thinking of." The group should continue guessing. To avoid excessive frustration, the leader may give hints as necessary.
- After leading one example of the game, have youth switch roles, giving each person at least one turn at being the "leader".

SHARE/PROCESS/GENERALIZE:

Help guide youth as they question, share, and compare their observations. You may choose one of the questions below as a prompt. If necessary, use more targeted questions as prompts to get to particular points. Remember these questions are not about getting one right answer. 3

- Describe the properties you guessed during the activity.
- Tell us about properties you found challenging to identify.

Facilitator Tip
Youth may include that hard or soft are properties that vary a great deal, for example a plastic cup is hard but can be flexible. A tennis ball is hard but has a soft, fuzzy cover. It is important to help youth consider how our descriptive words can be very essential.

- Describe if and why your group disagreed about a property.
- Explain the reasons why it might be difficult to identify a specific property. 3

Youth may realize that properties can exist to differing levels or degrees. For example, that hardness varies, that absorbent can describe something that is more or less absorbent than something else, such as a piece of cloth vs. a paper towel vs. a sponge.

3 SciGirls
Embrace struggle, overcome challenges, and increase self-confidence in STEM

Introduce the I Wonder Board to the group
Explain that there are practices that scientists and engineers use as they think and work.

One of those practices is to ask questions and define problems. (The facilitator would start the list of science and engineering practices here) We want to capture our wonderings and questions onto a tool called an "I Wonder" board (large flip chart paper or poster board with the words "I Wonder…" across the top).

On the board, collect the young people's questions or wonderings. Youth can print their own thoughts on sticky notes to put on a larger board, write directly on the board, or have an adult write for them. Examples of prompts adults can use are:

- What were you curious about as we did this activity?
- What did you wonder about?
- What questions did you have about the objects?

To help build understanding of application in real-world settings, show the short video from a scientist (see materials list). This scientist will describe what they do, what they are curious about, and how they carry out investigations in the lab or in their research.

Show 4-5 minute video: Meet a Scientist! 6
Alternate activity: if no internet connection is available, use the Scientist Story (Appendix A) by reading it aloud with the group, or making copies and having youth read it aloud.

Science and Engineering Practices
One of the science and engineering practices is to ask questions and define problems.

6 SciGirls
Interact and learn from diverse STEM role models

Use the questions below to engage youth in a discussion:

- What is the problem this scientist identified? (Note that one of the science and engineering practices is to ask questions and define problems).
- What are some of the ways the scientist conducts an investigation? (You will return to these after Activity C, so you will want to write them on chart paper or a whiteboard).
- What are some challenges scientists face?
- What did you hear about why this person enjoys being a scientist?

Science and Engineering Practices
Add 'Asking questions and defining problems' to science and engineering practices list or note it on the poster.

3 SciGirls

Embrace struggle, overcome challenges, and increase self-confidence in STEM

Activity C

Be a Slime Scientist (45-60 minutes)

In Part 1, youth engage in the practices of science and engineering by creating slime and then analyzing its characteristics. Note: If there are time constraints for your group, an alternate approach is for the facilitator to pre-make a batch of slime for Part 1.
In Part 2, youth create a different slime, using their data and a choice of ingredients to create a slime to their specifications.

Facilitator Tip
If possible, do not reveal to youth that they will create a different slime. You might instead explain that after analyzing characteristics, the youth will receive a challenge as a "slime scientist."

OPENING QUESTIONS/POSSIBLE PROMPTS

Facilitate a group discussion to get youth thinking about what they know about the main learning objectives of the module. You may ask the following prompts.

- What comes to mind when you hear the word experiment. (Prompts: Where do they occur? Who does them?)
- Describe any experiences you have had with doing an experiment.

PROCEDURE (EXPERIENCING):

PART 1

1. Connect the word 'experiment' to 'investigation.' Explain that scientists and engineers ask questions and define problems, they then plan and carry out investigations. Explain to youth that their task is to investigate slime. Gather background knowledge youth have about slime and if they have ever created it before.

   Youth must conduct tests to determine what properties slime has.

2. Divide youth into pairs. Pairs will follow the recipe for slime (Appendix B) to create their batch of slime. 5

Facilitator Tip
If desired, the facilitator could make the borax solution for the whole group ahead of time.

3. Youth will conduct slime tests using the Slime Test Observation Sheet (Appendix C) or a similar chart created on chart paper/white board. Explain that obtaining information is a science and engineering practice (add to list or point out on the 8 Practices of Science and Engineering poster). 2 Each pair should conduct each test and record their observations. This offers practice in acting like scientists, as scientists must make observations using their senses (not taste!). Scientists and engineers communicate information to others from their investigations so recording information (data) is an essential element.

Science and Engineering Practices
Add 'Obtaining and Communicating Information' to your list of practices, or point out on the 8 Practices of Science and Engineering poster.

Facilitator Tip
While most of the slime observations will be similar amongst your group, practicing this skill is important for the next activity, in which youth will create a unique recipe and conduct their tests on different types of slime. Collecting and recording data will be important in order to share their results with the rest of the group, and to analyze similarities and differences based on the "recipe" used.

4. Bring the whole group back together to discuss the slime creation and tests. Use these questions as a guide:
   - What did you observe as you went through the different steps of creating your slime?
   - What challenges, if any, did you encounter?

5 SciGirls
STEM is collaborative, social, and community-oriented

2 SciGirls
Support as they investigate using STEM practices

- Explain how well your slime turned out. What criteria did you use? Explain what happened or why you think it did or didn't.
- Looking at the data you collected on your slime test observation sheet, what did you learn? Do you think you could change slime?

Facilitator Tip
Try to guide students to connect that if they changed the recipe, they could possibly change the results of their tests. Guide them to inquire if they want a desired effect, what could they do to cause that effect? (To invite inquiry based learning, ideally create a learning environment where the youth initiate making their own slime recipe and perceive it as "their idea.")

Science and Engineering Practices
Explain that scientists and engineers would do an experiment or redesign their plan more than once.

5. This is part of the engineering design cycle that involves planning, testing, redesigning, and retesting. Scientists may also change a variable in their experiment to see what results. They change one variable at a time so they can determine if the change has an impact on the results. In Part 2, youth will be challenged to identify criteria for their own slime recipe.

Facilitator Tip
You may want to introduce the term "**polymer**" here, if you haven't yet talked about polymers. A polymer is a long chain molecule, similar to a string of beads or a string of paper clips. The key points to introduce are that the polymers in glue are our base for slime, water helps the slime flow, and the borax/contact lens solution serves to connect the long chains and hold your substance together (cross-links). Module 2 explores the concepts of molecules, polymers and cross-linkers more deeply.

PART 2

1. Challenge youth to create a new slime recipe using basic slime building blocks. Youth will need to consider what design criteria or specifications they would like to achieve (e.g. very stretchy, will hold the shape of a ball and bounce, colorful, soft, nice smell, etc). Ask youth to share how they might like to change their slime. Next, have youth write out their criteria and recipe, using the A Different Slime Recipe template handout (Appendix D) or a science journal before getting any materials. Pairs can have another pair of youth check their recipe to ensure they have included the key elements. Facilitators can also check recipes as necessary. As student pairs check in with the facilitator to show their recipe, facilitators can ask youth to point out where they have used math during this process.

   Introduce that the students have just used their mathematical measurement skills as they have changed their slime recipe.

   Science and Engineering Practices
   One of the science and engineering practices is 'Using mathematical and computational thinking' which can now be added to the science and engineering practices list or noted on the poster.

2. Youth should create their recipe. If they find it is too sticky or too runny, the first technique to try is more kneading! Youth may also let their slime sit for 3-5 minutes then use their hands to warm and knead the slime. In addition, they can add ingredients and should note the change in their recipe (e.g. if the slime is too sticky after kneading, they may add ½ teaspoon borax solution or saline solution at a time until the slime is not sticky).

3. Once pairs are satisfied with their slime creation, they can start testing using the slime test observations sheet (Appendix C) or similar chart.

Facilitator Tip
The test results will vary greatly, depending on how many variables the youth changed in their recipes. These can be discussed and youth can show their slime as part of their evidence. Collecting and recording data is an important science skill and one way to give evidence when presenting your findings! Data helps youth analyze similarities and differences and to draw conclusions.

Facilitator Tip
To make this sharing process a little more active, you can invite the youth to think about what criteria they had for their slime, and respond to the following instructions:

- Stand up if you had a criteria to make a slime that was bouncy, like a super ball. Be prepared to describe what "bouncy" criteria means to you.
- Stand up if you had a criteria to make a slime that had a nice texture. Be prepared to define what "nice texture" criteria means to you.
- Ask if any youth had a different criteria, then ask youth to stand if they used that criteria. Stand up if you made a slime that didn't turn out exactly how you wanted it to. Ask these youth to talk about what their slime is like and what they wanted it to be like

SHARE/PROCESS/GENERALIZE

Help guide youth as they question, share, and compare their observations. You may choose one of the questions below as a prompt. If necessary, use more targeted questions as prompts to get to particular points. Remember these questions are not about getting one right answer. 2

- Describe what you created in your experiment.
- Describe the data you collected to test your slime.
- What happened as you made your "different slime"?
- What do you think was challenging about being a slime scientist? 3
- What do you think was rewarding or fun about being a slime scientist?

Science and Engineering Practices
Youth will likely be using the Practice of 'Analyzing and Interpreting Data' and 'Constructing Explanations' as they respond to these questions. Add these to the Practices poster or note them on the list.

2 SciGirls

Support as they investigate using STEM practices

3 SciGirls

Embrace struggle, overcome challenges, and increase self-confidence in STEM

Ensure Concept Understanding

At this point, it is important to ensure that the terms **criteria, engineer, polymer, properties**, and **scientist** have been discovered by or introduced to the youth. The goal is to have the youth discover terms and concepts on their own, defining them with their own words. After youth have stated and shared their understanding of the concepts, then you may introduce the terminology used by scientists to refer to the concepts. Facilitate a brief conversation on the importance of the concepts.

SCIENCE & ENGINEERING IN EVERYDAY LIFE — CONCEPT APPLICATION

Facilitator Tip
When engaging youth in inquiry-based learning, hands-on activities serve as vehicles for learning new concepts, knowledge, and skills; however, it is the application of new knowledge or skills to independent, real-world situations that is the critical factor in the learning process. Thus, to complete the cycle of experiential learning it is important to intentionally provide youth specific opportunities for authentic applications.

REFLECTION

Reflecting on experience is an essential part of learning and "making meaning of" an experience. Now is an opportunity to bring the youth together and discuss the things they experienced throughout the module. You may want to use a "circle share" process to facilitate this discussion. Have youth sit in a circle with you. Some general questions you can ask the youth include:

- Did you try something that you've never done before?
- What is something new you learned from the activities today?
- How were you a scientist or engineer today?
- Which of the eight practices of science and engineering did you use today?

EXTEND THE LEARNING

- **Science at Home** - These are possible extension activities that can be used with youth as time/interest allows. If you meet multiple times, you might invite youth to do a take home activity and have them report back or bring in an item as described. This helps support application of the concepts you've explored in this module. These activities are also shared on the Science at Home handout.

Facilitator Tip
Science at Home can be copied and sent home with the youth, or emailed. It includes a brief summary of the module and provides several activity ideas. It encourages families to engage in science learning together, supporting application of the concepts.

- **Service Learning in Action** - Planning and carrying out a service-learning project can be an exciting opportunity for youth to apply their learning as they work to address local and world needs. In Module 6: Service Learning, youth will dive deep into the experiential process by creating and carrying out a service project related to plastics. Below are some suggested activities and real-world service-learning examples that you can explore with your students related to plastics in our world.

- **Real-World Examples:**
Kids Make Slime for a Cause - Sara Mckee and Elise Lutchman transformed their perfect slime recipe into a money making business to support a worthy cause. After developing different types of slime, Sara and Elise sold containers to fellow students and donated 100% of their profits to Habitat For Humanity. To read more about their story, please visit:
Habitat for Humanity Halton-Mississauga. (2017, July 10). *Getting Slime-y For a Good Cause.*
https://habitathm.ca/single-post-2017-07-10-getting-slime-y-for-a-good-cause/

- **Turning Plastic Trash to Art** - Sean Connaughty has collected over 6,500 pounds of trash over 5 years from a Minneapolis lake. Not only does he create art from trash, (imagine McDonald's arches from straws), he shares the impact of this trash with the companies and consumers that produce the waste. Check out his story and ways you can make change happen at:
Ross, J. (2019). Lake Hiawatha's guardian artist uses sculptures to call attention to trash problem. *Star Tribune*. Retrieved February 21, 2020, from http://www.startribune.com/lake-hiawatha-s-guardian-artist-uses-sculptures-to-call-attention-to-trash-problem/559597982/

SERVICE IDEAS

- **Slime Business** - Put your sublime slime engineering skills to work by making slime to sell to friends and family. With slime profits, consider sponsoring an animal at your local zoo or nature center. You can also donate to organizations that help rehabilitate animals impacted by plastics.
- **Make A Plan** - Keep a plastic diary and list every piece of plastic that you touch in a day. Sort the plastics into two categories: plastics that can be used over and over again and plastics that are thrown away after one use. Make a plan on how you can reduce plastic items that are thrown away after just one use. Ask others to join your efforts. Read about the impact of plastic straws use here: https://www.washingtonpost.com/lifestyle/kidspost/plastic-straws-are-little-but-they-are-part-of-a-huge-problem/2018/09/07/63bfe44e-ac9f-11e8-b1da-ff7faa680710_story.html?noredirect=on
- **Informational Interview** - Interview a solid waste collector or school engineer and ask what are the most common plastics they see in the waste bin. Ask them for ideas to decrease the amount of plastics in the garbage. You can also conduct a waste audit - https://cleanriver.com/waste-audit-in-5-easy-steps/

SOURCES

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Science at Home

Be a Scientist: Module 1

Hello Families,

Your child is exploring science and engineering in
Sustainable Polymers: Plastics of the Future for a Green, Clean World.

This week in the **Be a Scientist** lesson, we learned what scientists do and how your child naturally uses scientific and engineering concepts as they explore and change their world through design and play. Your child then became a slime scientist as they tested slime materials using science and engineering skills. By using what they discovered, your child created their own improved slime to meet their specifications.

We hope you and your child will try one or more of these "Science at Home" activities. You get to have fun together making new discoveries while practicing science and engineering skills. Please ask your child to share what you did at our next session! Thank you!

Try these "Science at Home" Activities:

- Create your own slime at home. (You can find a variety of recipes and experiments at How To SMILE, a database of science, engineering and math activities created by science museums, at https://www.howtosmile.org/)
- Make different slime! https://littlebinsforlittlehands.com/homemade-slime-recipe/ has many slime adaptations using shaving cream, other add-ins to extend the experience.
- Learn about science careers: Watch a short video about a scientist or engineer who has a job that sounds interesting to you! Find videos about scientists and engineers at SciGirls http://www.scigirlsconnect.org/ or at Engineering-GoForIt! http://www.egfi-k12.org/engineer-your-path/on-the-job/on-the-job
- Create Slime Art: Dry thin sheets of colored slime into art. You will need 1-2 days drying time. Find directions at https://www.stevespanglerscience.com/lab/experiments/slime-art/

References:

Brabandere, S., & Science Buddies. (2017). Slime: Is It a Solid, Liquid--or Both? Retrieved from https://www.scientificamerican.com/article/slime-is-it-a-solid-liquid-or-both/

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Appendix A

A SCIENTIST STORY: 3M CHEMIST BRIDGETTE SHANNON

http://www.scigirlsconnect.org/resources/chemist-bridgette-shannon/

Bridgette's formula for success is using her love of chemistry to develop groundbreaking products at work and create natural remedies for her family at home. She shares her story on PBS SciGirls.

Hi, my name is Bridgette Shannon and I am a product development specialist at 3M. I have a Bachelors in Chemistry and Ph.D. in inorganic chemistry and that is essentially everything on the periodic chart.

As a product development specialist in the 3M's Abrasive Systems Division, I work on developing the grain or mineral that goes into products like sandpaper or the grinding tools that does all the surfacing on metal and wood. This is the shaped ceramic grain, so this is an example of the types of minerals that I develop in the lab. We take the mineral and put it into a grinding wheel and we design this mineral for faster cutting, longer life time, so that they are more productive.

I love the fact that I turn an idea into an actual product that people can use in every day, so in a sense I am changing people lives.

I grew up in Little Rock Arkansas with my seven brothers. I am next to the youngest. I would say that I was a rough little girl, I tried to keep up with the boys and do what they did. I am very close with my family and what it taught me, as a woman, is to be there for one another and always make sure that we are there helping one another and that's why I like to help people today. And also, it taught me to stand up for myself because I had to stand up for myself being the only girl with those boys.

Appendix A
(Continued)

I first fell for Chemistry in high school when I had a really good chemistry teacher. She taught chemistry in a fun way. Chemistry is everything we do. You are able to make any product or build anything. It's everywhere. It is all around us and that was fascinating to me.
The best part of my job is being able to go to the Performance Test Center and determine whether or not the mineral I made is going to help make someone's life easier. The mineral that we made to do the cutting is actually designed for a faster and cooler cut, and that is exactly what you just saw here with the robot.

After I finished undergraduate school, I took a job working at L'Oreal manufacturing plant in their lipsticks division. I really loved working on makeup products, because it is something that I could use everyday, so it was cool. My husband is also a scientist who works for 3M. We have two boys: D.J. who's 11 and Jackson who's 3 and then we have one on the way.
One of the things I like to do in my spare time is make my own skincare products and today I am going to make a soothing ointment. My youngest is sick with a cold and so I want something that is calming, a light soothing ointment that helps him sleep at night.

I had a challenge of not being able to find things that I need on the shelf, so I decided to modify my own. And what I like best about that is that I can control what goes into it.

My advice to young girls would be first off, never give up. Sometimes things may seem hard, but everything takes time and secondly, build a support team. Surround yourself around positive people, people that are going to help you and uplift you and keep you encouraged to push forward.

Appendix B

SLIME Recipe-Part 1

Each pair will follow this recipe exactly for Part 1 of the activity:

Directions

1. Prepare Borax solution. If the Borax solution has already been prepared by your leader, begin with Step 2.
   - ☐ Measure ½ teaspoon of 20 Mule Team borax and pour it into the small container or cup.
   - ☐ Measure 2 tablespoons of water and add to the small container/cup.
   - ☐ Stir the borax and water well, for one minute, until all or most crystals dissolve. Set aside when done. Some of the borax crystals may not dissolve.
2. Pour 4 tablespoons (¼ c.) of glue into a new plastic cup.
3. Add 4 tablespoons (¼ c.) of water to glue and stir to mix well.
4. If you would like colored slime, add 2-3 drops of food coloring to the glue and water mixture and stir until mixed.
5. Continue stirring and slowly pour 2 tablespoons borax solution into the glue solution. Try to pour the borax solution all around the plastic cup, and leave any undissolved particles of borax in the small container.
6. Mix well. You will need to squeeze and knead the slime with your hands to make sure it's well mixed. You may want to scoop the slime onto a plate or piece of plastic/wax paper so it's easier to knead.

Caution:

Remember to keep your slime away from your eyes, and the carpet and furniture.
Wash your hands after working with your slime.

Appendix C

SLIME Tests Observation Sheet

Conduct each of the following tests. Observe what happens and record your observations in the blank boxes.

TEST	SLIME 1 OBSERVATIONS	SLIME 2 - "BETTER SLIME" OBSERVATIONS
DESCRIPTION (Color, texture, odor, other)		
SLOW POKE TEST (slowly poke one finger into the slime; repeat 3 times)		
QUICK POKE TEST (quickly poke one finger into the slime; repeat 3 times)		
SLOW PULL TEST (slowly pull on a piece of slime; repeat 3 times)		
QUICK PULL TEST (quickly pull on a piece of slime; repeat 3 times)		
BLOB TEST (let your slime sit for 2 minutes on a hard surface)		
BOUNCE TEST (roll your slime into a ball and drop on the table surface)		

Appendix D

Be a Scientist: A Different Slime!

Use the data you collected from your slime observation sheet to help you adjust the ingredients to fit your desired criteria.

Step 1: Determine the changes you want to make:

Step 2: Determine the criteria you want to achieve in your new slime recipe:

Texture:

- ☐ Very stretchy
- ☐ Will hold the shape of a ball and bounce
- ☐ Sticky
- ☐ Not sticky
- ☐ Easily molded
- ☐ Thick consistency
- ☐ Spreads like a liquid

Beauty:

- ☐ Colorful
- ☐ Soft
- ☐ Nice smell
- ☐ Other:

Step 3: Use the following findings to determine the ingredient amounts and how the ingredients impact the slime.

Findings:

- A higher concentration of borax in solution may result in a harder material
- Less contact lens solution may make the slime more flexible
- More baking soda may make slime less sticky
- Use borax solution instead of dry borax to make the slime more bouncy
- Kneading the slime helps to make it smooth.

Step 4: Create your different recipe.

Appendix D
Recipe: My Different Slime

Ingredients:

1. 1/4 c. of Glue
2. 1/4 c. (4 tablespoons) water
3. Cross linker option
4. Color or texture options

Directions:

1. **START with the base slime recipe: Pour 1/4 cup glue into container.**
2. **Add 1/4 c water. Mix completely.**
3. **Circle one cross linker option below to try:**
    a. 1 tablespoon borax solution
    b. 1/2 tablespoon borax solution
    c. 1/4 teaspoon baking soda + 1 tablespoon of contact lens solution
    d. 1/4 teaspoon baking soda + 2 tablespoons of contact lens solution
    e. ½ teaspoon of dry borax

Add 1 or 2 color texture options. Record what you added and the amount:

Record what happened as you made your different slime:

Texture:

Beauty:

Other:

How did it meet your desired look and feel (criteria)?

The SciGirls Strategies

Proven Strategies for Engaging Girls in STEM

The **SciGirls** approach is rooted in research about how to engage girls in STEM. A quarter of a century of studies have converged on a set of common strategies that work, and they have become the framework for **SciGirls**. The original set of strategies, created in 2010, were updated in 2019 to reflect current research.

1

Connect STEM experiences to girls' lives.

(Boucheretal.,2017;Sammetetal.,2016;Bonner&Dornerich,2016;Ereteetal.,2016;Stewart-Gardineretal.,2013;Civil,2016;Verdinetal.,2016;Cervantes-Soon,2016).

Make STEM real and meaningful by engaging girls in activities that draw on their interests, knowledge, skills, culture, and lived experiences. This helps girls develop a STEM identity and increases their sense of belonging in STEM.

2

Support girls as they investigate questions and solve problems using STEM practices.

(Buckholz et al., 2014; Kim, 2016; Scott & White, 2013; Farland-Smith, 2016; Munley & Rossiter, 2013; Civil, 2016; Riedinger et al., 2016)

Engage girls in hands-on, inquiry-based STEM experiences that incorporate practices used by STEM professionals. Let girls take ownership of their own STEM learning and engage in meaningful STEM work to positively impact their identities and re-define how they see STEM.

3

Empower girls to embrace struggle, overcome challenges, and increase self-confidence in STEM.

(Blackwell et al., 2007; Dweck, 2000; Halpern et al., 2007; Kim et al., 2007; Mueller & Dweck, 1998)

Help girls focus on and value the process of learning by supporting their strategies for problem solving and letting them know their skills can improve through practice. Support girls to develop a growth mindset—the belief that intelligence can develop with effort and learning.

4

Encourage girls to identify and challenge STEM stereotypes.

(Allenetal.,2017;Carlietal.,2016;Cheryanetal,2015;Robnett,2016;Allenetal.,2017;Carloneetal.,2015;Sammetetal.,2016,Scottetal.,2014;Tanetal.,2013;Dasguptaetal.,2014;Verdin et al., 2016; Civil, 2016; Boucher et al., 2017)

Support girls in pushing against existing stereotypes and the need to conform to gender roles. Helping girls make connections between their unique cultural and social backgrounds and STEM disciplines will negate potential stereotype barriers.

5

Emphasize that STEM is collaborative, social, and community-oriented.

(Capobiancoetal.,2015;Diekmanetal.,2015;Leaper,2015;Riedingeretal.,2016;Robnett,2013;Parker&Rennie,2002;Scantlebury&Baker,2007;Werner&Denner,2009;Cakiretal.,2017; Sammet et al., 2016; Boucher et al., 2017; Clark et al., 2016; Leaper, 2015)

Highlight the social nature of STEM to increase interest and motivation and change the stereotypical perception that STEM jobs require people to work alone. Girls benefit from a supportive environment that offers opportunities to build relationships and form a collective identity.

6

Provide opportunities for girls to interact with and learn from diverse STEM role models.

(Kochetal.,2015;Leaper,2015;Adamsetal.,2014;Jethwanietal.,2017;Kessels,2014;O'Brienetal.,2016;Levineetal.,2015;Hughesetal.,2013;Cheryanetal.,2015;Weisgram&Diekman,2017)

Introduce girls to diverse women role models from varied STEM career pathways to help girls see potential futures and develop resilient STEM identities. Positive role models can increase girls' interests in, positive attitudes toward, and identification with STEM.

Send us your Feedback!

Have you tried one (or more!) of the activities? Let us know how it went! We work with the Center for Applied Research and Education Improvement at the University of Minnesota to evaluate this project. Click on the button below to fill out their short evaluation form and help us collect valuable feedback for improvement!

4hpolymers.org/evaluation

NATIONAL PEER REVIEWED

MODULE 2

GRADES 3-5

Sustainable Polymers

Plastics of the Future for a Green, Clean World

A 4-H STEM Curriculum for Grades 3-5 | 4hpolymers.org

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4-H Polymer Science Curriculum for

Grades 3-5

4hpolymers.org

The themes of these modules touch on the prevalence and impact of plastics in everyday life. Plastics are versatile materials that come in different shapes, sizes, and exhibit different material properties. Scientists and engineers are working on new ways to create, use, and recycle plastics, so we can use plastics for their many advantages and lessen their effects on our environment.

Each module will include "Tips for Facilitators" and the Science and Engineering Practices, as well as opportunities to use "I Wonder" Boards. In addition, these modules incorporate the SciGirls Strategies for gender equitable STEM learning. We encourage instructors to collect feedback throughout this module and submit via this evaluation form: **4hpolymers.org/evaluation**.

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Tips and Callouts

Facilitator Tips

These tips provide strategies and helpful suggestions for facilitators.

"I Wonder" Boards

These boards should be used to track children's questions and ideas during the lesson for further investigation. This tool promotes experiential learning by youth while encouraging curiosity and discovery. Basic "I Wonder" Boards have "I Wonder..." written at the top of a large sheet or white board.

Science and Engineering Practices

The Next Generation Science Standards (NGSS) identifies eight practices of science and engineering that are essential for all students to learn. Using these practices, youth make sense of phenomena and use these skills to investigate the world and design and build systems.

SciGirls Strategies

Based on educational research, the SciGirls Strategies are used to target and engage girls in STEM learning, but have also been proven to work with all learners, including underrepresented youth. See the SciGirls Strategies handout at the back of the module for a more detailed explanation.

Module 2

Materials Matter
Primary Authors: Anne Stevenson
Contributing Authors: Amie Mondl, Kelly Strei

Introduction

MODULE SUMMARY

Youth explore materials and their properties, and explore the concepts of monomer, polymer, and molecule. Youth investigate how chains of molecules that make up polymers and plastics affect the function of an object, and conduct a test to see how heat affects different types of plastics. Youth discover the wide range of functions of polymers and consider some of the benefits and challenges of this material.

Total lesson time needed for Module 2: 65-90 minutes not including set up time
Getting Ready: 35-45 minutes total

- Activity A: Cup Wars (15-20 minutes)
- Activity B: What's the Science Behind Cup Wars? (15-20 minutes)
- Activity C: Polymers – One Type of Material (10-15 minutes)
- Activity D: A Stop at the QuickShop Store (15-20 minutes)
- Reflection/Wrap Up (10-15 minutes)

Total estimated time for Module 2*:* **100-135** minutes, including set up time

Module Focus

LEARNING OBJECTIVES	• Youth will understand that materials (and all matter) are made of smaller building blocks (particles) that are too small to see • Youth will discover that polymers are long chains of repeating units • Youth will explore how materials & their properties influence their function or purpose
SCIENCE AND ENGINEERING PRACTICES *Youth will engage in the following NGSS Practices:*	• Developing and using models • Asking questions • Analyzing and interpreting data • Constructing explanations (for science) and designing solutions (for engineering) • Engaging in argument from evidence
CONCEPTS & VOCABULARY	• **Atom:** the basic unit of a chemical element; the smallest component of an element • **Function:** the purpose of an object or what it is used for • **Material:** a physical substance of which something is made or can be made; wood, plastics, glass, and metal are some examples of materials • **Matter:** Anything that takes up space is called matter. (Air, water, rocks, and even people are examples of matter); matter can exist in one of three main states: solid, liquid, or gas *Continued on next page*

Module Focus (Continued)

CONCEPTS AND VOCABULARY

- **Molecule:** the smallest unit of a substance that has all the properties of that substance; made up of two or more atoms
- **Monomer:** a part or single unit ('mono' means one and 'mer' means unit)
- **Natural Polymer:** a type of polymer that comes from nature
- **Polymer:** large molecule made of long chains of repeating parts. Each repeating unit is the "monomer," so polymer=many repeating units
- **Properties:** characteristics that can be observed or measured; properties include size, shape, density, texture, hardness, color, odor, and other ways something looks or feels
- **Synthetic Polymer:** a type of polymer made up of chemical compounds discovered by scientists; "human-made" rather than occurring in nature

Facilitator Preparation

MATERIALS - ACTIVITY A – CUP WARS

- ☐ One PLA (bioplastic)cup (identified as Sample A) - 1 per group of three youth
- ☐ One polystyrene (PS) cup (identified as Sample B) - 1 per group of three youth
- ☐ One other plastic cup (identified as Sample C) - 1 per group of three youth
- ☐ Permanent marker, black or blue - 2-3
- ☐ Blow dryer - 2-3
- ☐ Cup Wars Data sheet-Appendix A - 1 per group
- ☐ Pens/pencils - 1 per group

Note: Sample A is made of polylactide (also called poly lactic acid, and should say PLA on the bottom of the cup); Sample B is made of polystyrene and will say PS on the bottom. (e.g. white styrofoam cup) Provide one additional type of plastic cup (Sample C), such as Solo™ cups, Dixie™ cups, or any other plastic or paper beverage cup

GETTING READY (10-15 MINUTES)

- Use a permanent marker to label cup samples with A, B, or C on the bottom
- Set up equipment (hair dryers, cups); for larger group you may wish to set up three stations (one for testing Cup A, one for B & one for C), and have youth rotate through the stations to conduct their tests
- Test sample C prior to the lesson, using the hair dryer test, so you know what will happen; for example, a Solo ™ brand cup may show some melting; heating a Dixie ™ brand, wax-covered paper cup may cause the wax to soften and become warm; other cups will vary so facilitator should test before using
- Put youth in groups of three 5

5 SciGirls

STEM is collaborative, social, and community-oriented

Facilitator Preparation (Continued)

MATERIALS - ACTIVITY B – CUP WAR SCIENCE

- ☐ Bandanas, 12-15 (or strips of cloth approximately 12” x 4” if bandanas aren’t available)

GETTING READY (5 MINUTES)

- Gather supplies listed under the materials list

MATERIALS - ACTIVITY C – POLYMERS – ONE TYPE OF MATERIAL

- ☐ A variety of common plastic items: rubber bands, bouncy ball, tiny rubber Lego tires, a football, CD case, styrofoam pool noodle or cup, fleece jacket, nylon fabric, rubber spatula, a plastic bag, plastic cup, a bio-plastic cup
- ☐ Alternate option, if unable to gather items, is to print off Appendix B photo cards

GETTING READY (10-15 MINUTES)

- Gather supplies listed under the materials list
- If needed, print Appendix B photo cards

MATERIALS - ACTIVITY D - STOP AT THE QUICKSHOP STORE

- ☐ Print copies of Appendix C
- ☐ Small stickers for voting, 1 per youth
- ☐ Chart paper

GETTING READY (10 MINUTES)

- Gather supplies listed under the materials list
- Print copies of Appendix C

Background Information for the Facilitator

Polymers are in almost everything we use in our everyday life. A polymer is a large molecule made up of long chains of repeating units. Each unit, or repeating part, is a monomer. The word 'mer' means unit, and 'mono' means one.

A **molecule** is the smallest unit of a substance that has all the properties of that substance. For instance, a water molecule is the smallest unit that is still water. A water molecule can be divided into tiny parts called **atoms**. Each water molecule has two hydrogen atoms and one oxygen atom (thus water is written as H_2O). **Atoms** are the smallest building block of all matter. Molecules are made up of two or more atoms that bond together. **Matter** is made of atoms and is anything that takes up space (air, water, rocks and even people are examples of matter). Matter can exist in one of three main states: solid, liquid, and gas.

Materials are the physical substance of which a thing is made or can be made. Wood, plastics, glass, and metal are some examples of materials. The **properties** of polymers reflect what's going on at the ultra-tiny (molecular) level. So, polymers look, feel, and act differently depending on how their atoms and molecules are connected, as well as which molecules they're made up of! This makes polymers a very useful type of material - they can have many different **properties** and **functions**. Some polymers are stretchy like a rubber band, rubbery like a bouncy ball, tough like a football, hard and tough like a skateboard, soft like a sweater, silky and strong like a parachute, or even bulletproof.

There are **natural polymers** (which come from nature) and **synthetic polymers** (chemical compounds discovered by scientists and produced in a factory or laboratory). While plastics are one common example of polymers, there are many other materials which are also polymers. Examples of **natural polymers** include rubber (from the sap of rubber trees) and silk (from the cocoons of silkworms), starches in plants such as corn, and cellulose found in paper and trees. Polymers also include proteins (such as hair, nails, and tortoise shell). Scientists combine monomers into a variety of different polymer arrangements to make **synthetic polymers** that can be molded into solid objects or films. These materials are known as plastics. All plastics are polymers. Examples of plastics include polyvinyl chloride (PVC), polystyrene, and polyethylene. Although all plastics are polymers, not all polymers are plastics. Other examples of synthetic polymers are nylon, polyester, and silly putty. Because synthetic polymer chains are designed to specifically meet desired characteristics (strong, flexible, translucent, resistant to heat, etc.), the final polymer chain can be very strong and difficult to breakdown naturally (via UV rays, heat, bacteria, or water).

Two short videos from National Geographic provide helpful background for facilitators.
Plastic 101 found at: https://www.youtube.com/watch?v=ggh0Ptk3VGE&t=74s
A Brief History of How Plastic Has Changed Our World found at: https://www.youtube.com/watch?v=jQdBag_p6kE

“I Wonder Board”

While the professional science and engineering communities often require specialized training and tools, anyone can learn to engage in similar processes and practices! Activities encourage “wondering” and emphasize how important it is for adults to model and encourage curiosity in youth. These “wonders” are often turned into questions that can be investigated or studied. Consider posting an “I Wonder” board (see Front Matter for full explanation) to help surface these “wonders” and perhaps provide inspiration for your group to dig deeper into their curiosities.

Activity A

Cup Wars
(15-20 minutes)

Youth will test how heat affects different types of plastics, exploring how the properties of materials affect its function.

Facilitator Tip
Depending on the size of your group, you may want to set up three stations so youth can rotate in small groups, with one station for testing Sample A, one station for Sample B, and one for Sample C.

OPENING QUESTIONS AND PROMPTS

Use the following prompts to facilitate a group discussion to get youth thinking about what they know about the main learning objectives of the module. 1

- What are 3 different containers that you have used for a beverage in the last week? Explain why you chose that type of container.
- If you were having a party and you wanted to serve beverages, what types of containers might you choose?
- What would influence the type of container you'd choose?

Facilitator Tip
Refer back to the Scientist Story in Module 1 if your group has viewed the video or read the story. Chemists and Chemical Engineers rely on the composition of a material - its chemical structure and what it is made from - to design what a material looks like, how strong it is, what it feels like, and to have it perform specific functions.

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Explain the challenge: Your team is challenged to find out which plastic cups can hold a hot liquid (such as hot tea or hot cocoa).

To ensure safety in this activity, ask the group:

- What are some ways we could test these three cups to see how they withstand heat (like hot liquid)? (Youth will likely say we could pour hot water in them and watch what happens).
- Would there be any safety concerns with each type of test? (burn our hands, have hot water run all over)
- Emphasize that safety is a key consideration for any experiment. Scientists and engineers have to be sure that any experiment or test they try is safe. To keep us safe, we will be using a hair dryer for the heat source, instead of hot water.

PROCEDURE (EXPERIENCING)

1. Invite youth to examine each type of cup (Samples A, B & C), then answer the following questions, and make brief notes about the cups' appearance (size, texture, color, weight, and other observations) on the Cup Wars data sheet. Alternatively, you might want to have this conversation as a full group and record notes on flip chart paper.

2. Engage in group discussion, using these questions:
   - Based on appearance alone, what is the same and different with the three cups?
   - Do you think these are made of the same material? Why or why not?
   - Based on your observations, predict how each sample will hold up to the heat of the hair dryer.

3. Give a safety demonstration: Show youth how to hold their cups and blow dryer -- the youth can hold the cup right next to the blow dryer, but should keep their fingers out of the hot air. It can help to hold the cup upside down by the lip.

4. Invite each group to move to stations and to blow-dry their sample cups for 30 seconds. (Groups can repeat for another 30 seconds, observing at the end of each 30 second test. They may repeat for up to a total of 120 seconds or 4 sets of 30 seconds each). Guide youth to rotate to all three stations. Ask youth to make notes about their observations using the Cup Wars Data Sheet (Appendix A).

Facilitator Tip
Sample A "flows" within about 20 seconds. This means the plastic will warp and collapse. Sample B should be impacted only in a minor way (if at all). The results for Sample C will depend on the type of cup chosen; facilitators will have tested this sample prior to youth trying it so they will know how it reacts to heat.

5. Based on their observations, have youth draw conclusions about the ability of the cups to hold hot water based on how they reacted to the blow dryer test. Ask them to explain their conclusions.

Science and Engineering Practices
Explain that scientists and engineers would do an experiment or redesign their plan more than once.

Facilitator Tip
Each group of three will spend about 30-120 seconds blow-drying each sample. What you should find is that Sample B is capable of holding a hot liquid, and Sample A is not. What about Sample C? (Because Sample C will vary based on the type of cup you have chosen, responses will vary also). For example, a Solo ™ brand cup will show some melting; testing a Dixie ™ brand, wax-covered paper cup may cause the wax to soften and become warm; other cups will vary so test before using.

SHARE/PROCESS/GENERALIZE:

Help guide youth as they question, share, and compare their observations. 2 You may choose one of the questions below as a prompt. If necessary, use more targeted questions as prompts to get to particular points. Remember these questions are not about getting one right answer. When the activity is completed, gather the whole group back together and lead a discussion with the following questions:

- Describe what happened with Sample A? Sample B? Sample C?
- What evidence did you gather through your observations that this cup would or would not hold hot liquid?
- Explain how these reactions are similar. Explain how they are different.
- What do you think causes the cups to react the way that they did?
- What do you notice about the plastic code on the cups we used?

Facilitator Tip
This may be a good time to discuss what materials plastics are made from: synthetic or "petroleum-based" are still our most common material to make plastics. PLA cups are plant-based plastics.

Science and Engineering Practices
Articulate for youth that they have used another Science and Engineering Practice: 'Engaging in argument from evidence' and add it to the list. 2

- Clarify that the word argument in this context is defined as reasons given to support an idea and that in the investigation they just did, the cups are evidence that the plastics are made of different compositions of material.

"I Wonder Board"
Use this opportunity to wonder aloud and model the process of wondering and asking questions; use the I Wonder board. Some things you may wonder aloud about with your group include: I wonder if all of these can be recycled? I wonder if it costs more to buy the plastic that can hold both hot and cold liquids? I wonder if it would be better for the earth to use a different type of container instead of plastic cups? I wonder what other experiments we could try to give us more data?

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Activity B

The Science Behind Cup Wars (15-20 minutes)

This activity helps demonstrate what is happening on a more molecular level and how different polymer structures result in different properties. Youth will first model a polymer chain by acting as "monomers," (single, repeating units, forming a chain) to form the polymer according to directions given by a facilitator. The facilitator will act as a chemist stringing the monomers into polymer chains. Youth will then draw from their experience from the plastic cup softening experiments and demonstrate what is happening to the polymer chains of a plastic cup (oil-based plastic) and a PLA cup (bio-based plastic) when heat is applied. Youth will learn about polymer chains and how they interact, and why plastics are functional as well as problematic for our earth.

OPENING QUESTIONS AND PROMPTS

Use the following prompts to facilitate a group discussion to get youth thinking about what they know about the main learning objectives of the module. 1

QUESTIONS BEFORE THE FIRST DEMONSTRATION OF A POLYMER CHAIN:

- Explain what you think might happen when you heat up a polymer.
- Explain how you think a scientist or chemist might change a polymer chain.

QUESTIONS BEFORE THE SECOND DEMONSTRATION OF POLYMER CHAIN WHEN HEAT IS APPLIED

- What do you think was happening to the PS plastic cup when it was softening/deforming?
- What do you think was happening to the PLA plastic cup when it was softening/deforming?

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PROCEDURE (EXPERIENCING)

Use the following prompts to facilitate a group discussion to get youth thinking about what they know about the main learning objectives of the module.

1. First polymer demo: Explain that we are going to create a "human model" to explore the science behind what happened in Cup Wars. Ask for at least six volunteers who are willing to become a polymer chain. Ask them to stand in a line facing the rest of the group. Each of the youth will be a "monomer." Explain that the facilitator will be the chemist arranging the polymer chain by stringing the "monomers" together. The role of scientist is important because he/she is building the different polymers to achieve a desired material characteristic.

2. Ask the youth to grasp hands. Ask one youth on one end of the "Mer-Chain" to pull on the hand of the person next to him/her while the other five youth pull in the opposite direction. Discover what happens. If the "link" (holding of hands) breaks, challenge the youth to explore other ways their chain can move together (e.g. stand closer or further apart). The "chemist" can assist in adjusting the polymer chain. Trying pulling away again. Discover what happens. Prompt by asking: How else could you create a "mer chain" from (human) monomers? (accept ideas that connect the monomers, such as the youth could hold each other's hands, which would form a bond between each of these monomers; youth could link elbows to form another type of bond; youth could both hold onto a piece of yarn, string, rope or rubber band, which would also link them into a chain).

3. Second polymer demo simulating a PS plastic cup: Now ask nine (or more) youth to form three different mer-chains. One youth acting as the "chemist" works with the group to make three very flexible and easy to move mer-chains. The goal is for the mer-chains to be organized into three lines that are shoulder distance apart. The members within each mer-chain lock elbows to stay connected to each other. Ask one additional youth to act as the heat from the hairdryer. The "hairdryer" makes a loud noise representing heat and tries to move the links of each mer-chain further apart, but each mer-chain is hard to move together because they are so close to the others.

4. Third polymer demo simulating a PLA plastic Cup: Youth stand close to the others in their chain, linked by holding the end of a bandana. The "chemist" arranges each mer-chain into a new structure using the bandanas, representing a plant-based polymer, such as the PLA cup. The mer-chains are again ordered into neat lines. The "hairdryer" again makes a loud noise representing heat and as a result, the chain linkages spread apart and the bandana bonds move apart. The three mer-chains should take three large steps away from each other and can now move in multiple directions.

SHARE/PROCESS/GENERALIZE:

Help guide youth as they question, share, and compare their observations. **2** You may choose one of the questions below as a prompt. If necessary, use more targeted questions as prompts to get to particular points. Remember these questions are not about getting one right answer.

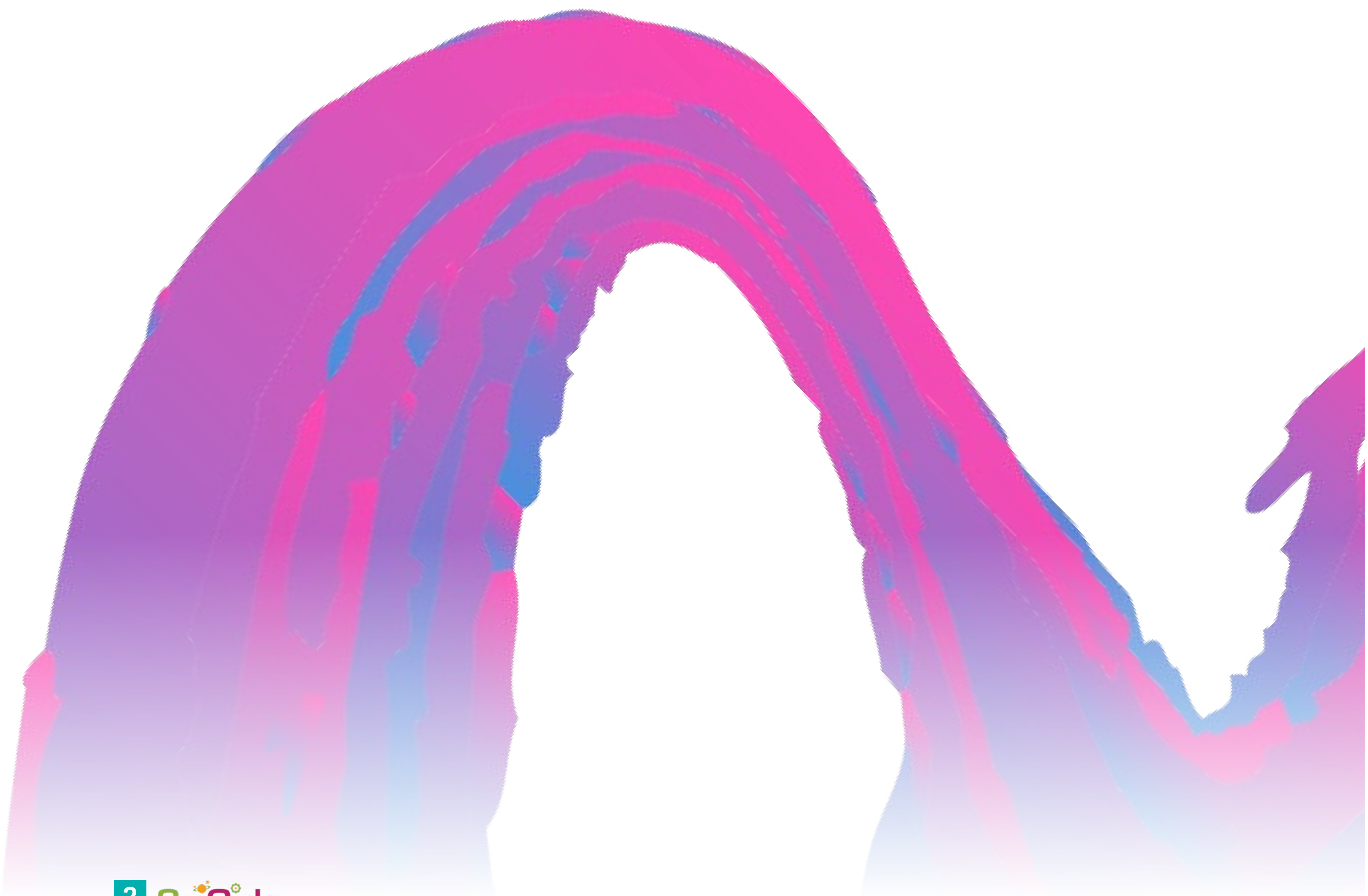
- Based on your experience from the activity,
  - Describe ways the hairdryer (heat) impacted the polymer chains of the plastic cup (cup B or C).
  - Describe ways the hairdryer (heat) impacted the polymer chains of the PLA plastic cup (cup A).
  - Explain how different bonds may have different flexibility. (Possible responses may include: the elbow linkage would be stronger than holding hands; holding hands would be stronger than joining index fingers. Possible explanations may include: the elbow bond puts people closer together; arm muscles are stronger than our hand muscles, certain linkages pull the chain closer together).
- Describe ways you were able to make the bonds more or less flexible. (Youth may describe ideas, such as having some people link to shoulders and others link by elbow, linking ankles by crossing their legs. Some of these may speak to how polymer chains can cross-link).

"I Wonder Board"
Challenge the group by modeling an "I Wonder" statement: Some materials need to function at high temperatures so how might we prevent the mer-chains from moving away from each other when heated?

Facilitator Tip
Using the human "mers" in your group, ask youth to demonstrate how they might cross-link with each other. Youth might link arms within their mer-chain and try to use a free hand to grab onto a different mer-chain, or they might use bandanas to tie chains together more tightly.

Science and Engineering Practices
Articulate for youth that they have just used another practice of science and engineering: 'Developing and using models.' Add this to the poster or list which was started earlier. 2

Summarize: We have discovered that polymers are long chains of molecules, which make them both very strong and durable. We learned that all plastics are made of polymers. Knowing this, share an example of how polymers could be helpful to us. Share an example of how polymers could be hurtful/harmful to us.



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Activity C

Polymers: One Type of Material (10-15 minutes)

In this activity, youth explore polymers as one type of material, and discover that objects made of the same material can have different properties and functions.

OPENING QUESTIONS AND PROMPTS

Look around the room. Name some of the materials that objects in this room are made of.

Facilitator Tip
Materials are the physical substance of which something is made; these include wood, glass, polymers, metals, paper, cloth/textiles, and composites (combinations of various materials).

PROCEDURE (EXPERIENCING)

1. Gather youth around a table or circle on the floor on which you've placed 8-15 assorted objects made of polymers (rubber bands, bouncy ball, fleece jackets, tiny rubber Lego tires, a football, a CD case, Styrofoam (pool noodle or piece of packaging), plastic bags, plastic cup (re-usable, such as a child's cup), a PLA cup, plastic utensil, plastic beverage / coffee cup, etc.). (For a group larger than 10, you might create two or three tables of objects and divide the group between the tables).
2. Ask youth to individually examine each object for about 30 seconds, noting object strength, object flexibility, object purpose, and other similarities and differences between the objects.

Facilitator Tip
Encourage youth to touch, squeeze, or bend the items.

3. Ask youth to describe the properties of the objects and discuss what materials they think the objects are made of.

> **Facilitator Tip**
> Youth may describe the items as stretchy like the rubber band, rubbery like the bouncy ball or Lego tire, tough like a football, and stiff like a plastic cup. The material that all of these items are made of is polymers. All plastics are polymers. Even when objects are made of the same materials, they might look different and have different properties and functions.

4. Next, ask youth to work together to sort objects into two piles – what do you keep (use over and over) and what do you get rid of after using it (single use)?

SHARE/PROCESS/GENERALIZE

Help guide youth as they question, share, and compare their observations. 2 You may choose one of the questions below as a prompt. If necessary, use more targeted questions as prompts to get to particular points. Remember these questions are not about getting one right answer.

- Ask youth to share their observations about the objects and why they would keep or toss it.
- Discuss any disagreements youth had over how they sorted the objects. 3

Explain that this challenge, to decide what to do with objects once we are done with them, is one that we are faced with each day. When scientists and engineers think about sustainability, they need to consider what materials something should be made out of, how an item is made, and what happens to it once it is no longer needed. These criteria are important when we want to take care of our planet Earth.

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3 SciGirls

Embrace struggle, overcome challenges, and increase self-confidence in STEM

Activity D

A Stop at the QuickShop Store (15-20 minutes)

Youth will learn about three materials and their properties: plastic, aluminum, and glass. Youth will consider the advantages and disadvantages of the material, and present an argument for what they understand to be the best option.

Facilitator Tip
Consider bringing in actual examples of food in packaging, such as metal cans or glass jars of food, different beverage containers, aluminum pouches, etc. to help youth visualize the wide variety of packaging materials.

OPENING QUESTIONS AND PROMPTS

- Describe different types of materials we use in our everyday lives to package food products. 1
- Explain why you think different materials are used.

PROCEDURE (EXPERIENCING)

1. Read aloud the following challenge to the youth:

   You are out for a walk and are really thirsty. You want something to drink, and your reusable water bottle is empty. The QuickShop convenience store is just down the street. Your favorite beverage comes in three different containers – glass, plastic and aluminum – and all contain the same amount. You also have your reusable water bottle. Which of the four would you choose for your drink?

2. Ask the youth to identify some of the criteria they would use to make their choice.

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Facilitator Tip
You may need to clarify that you are not asking them to state what is good or not-so-good about the containers, but rather that criteria is a standard by which something can be judged or evaluated, so as a group we are identifying how we might judge the four options. If needed, you may prompt the discussion by stating a criteria, such as cost.

3. Divide youth into four smaller groups, with no more than four youth per group. 5 If you need more than four small groups, two groups can have the same beverage container handout (i.e. two groups will have glass).
4. Give each group a paper (Appendix C) with one type of beverage container and facts about that product listed on it.
5. Challenge each group to read the facts listed and discuss the advantages and disadvantages of their container. Give them 4-5 minutes to discuss and decide how to present their facts and opinions to the full group.
6. Have youth present their information to the full group.
7. After the four groups present, youth will be asked to choose which container they believe is the wisest choice and be prepared to explain why.

(Use the flip chart paper to have each youth cast their vote. List each option and ask each youth to use a sticker to vote. You could also create a chart/graph of your votes).

Science and Engineering Practices
One of the science and engineering practices is 'Using mathematical and computational thinking' which can now be added to the science and engineering practices list or noted on the poster.

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STEM is collaborative, social, and community-oriented

SHARE/PROCESS/GENERALIZE

Help guide youth as they question, share, and compare their observations. 2 You may choose one of the questions below as a prompt. If necessary, use more targeted questions as prompts to get to particular points. Remember these questions are not about getting one right answer.

- Explain what you think were the most important criteria or properties for the container voted to be the "Best".
- Describe your reasoning behind your choice.
- Explain where you think the different containers would end up once they are empty. Describe any disagreements you had with your groups' list of advantages and disadvantages. 3
- Explain any challenges you faced when making a decision about the "best" container. 3
- Explain how this activity may influence your choices or your family's choices in the future. 1

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2 SciGirls

Support as they investigate using STEM practices

3 SciGirls

Embrace struggle, overcome challenges, and increase self-confidence in STEM

Ensure Concept Understanding

At this point, it is important to ensure that the terms **atom, function, matter, materials, monomer, natural polymer, polymer, properties, and synthetic polymer** have been discovered by or introduced to the youth. The goal is to have the youth discover terms and concepts on their own, defining them with their own words. After youth have stated and shared their understanding of the concepts, then you may introduce the terminology used by scientists to refer to the concepts. Facilitate a brief conversation on the importance of the concepts.

SCIENCE & ENGINEERING IN EVERYDAY LIFE - CONCEPT APPLICATION

Facilitator Tip
When engaging youth in inquiry-based learning, hands-on activities serve as vehicles for learning new concept knowledge and skills; however, it is the application of new knowledge or skills to independent, real-world situations that is the critical factor in the learning process. Thus, to complete the cycle of experiential learning it is important to intentionally provide youth specific opportunities for authentic applications.

REFLECTION

Reflecting on experience is an essential part of learning and "making meaning of" an experience. Now is an opportunity to bring the youth together and discuss the things they experienced throughout the module. You may want to use a "circle share" process to facilitate this discussion. Have youth sit in a circle with you. Some general questions you can ask the youth include:

- Did you try something that you've never done before?
- What is something new you learned from the activities today?
- How were you a scientist or engineer today? 4
- Which of the eight practices of science and engineering did you use today? 2

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4 SciGirls

Identify and challenge STEM stereotypes

EXTEND THE LEARNING

- **Science at Home** - These are possible extension activities that can be used with youth as time/interest allows. If you meet multiple times, you might invite youth to do a take home activity and have them report back or bring in an item as described. This helps support application of the concepts you've explored in this module. These activities are also shared on the Science at Home handout.

> **Facilitator Tip**
> **Science at Home** can be copied and sent home with the youth, or emailed. It includes a brief summary of the module and provides several activity ideas. It encourages families to engage in science learning together, supporting application of the concepts.

- **Service Learning in Action -** Planning and carrying out a service-learning project can be an exciting opportunity for youth to apply their learning as they work to address local and world needs. In Module 6: Service Learning, youth will dive deep into the experiential process by creating and carrying out a service project related to plastics. Below are some suggested activities and real-world service-learning examples that you can explore with your students related to plastics in our world.

- **Real-World Examples:**

  Isatou Ceesay in Njau, Gambia transforms discarded plastic bags into colorful purses. By turning plastic waste into useful products, Isatou also transformed her community. Check out her story at http://oneplasticbag.com/ or read the book One Plastic Bag.

  Liz Houck Kampa of St. Cloud, MN founded Weaving Love Inc., an organization that weaves plastic bags together to make rugs for the homeless. Check out her website at www.weavinglove.com

SERVICE IDEAS

- **Straw Reduction** - We all love straws, but what materials are they made of and how long is their lifecycle after we throw them away after just one use? Explore reusable alternatives to plastic straws. Tell a friend or others about what you've learned.

- **Ditch Plastic Shopping Bags** - Plastic shopping bags can pile up after just one use. They are not easily recycled and often end up in the ocean or landfills where they can be deadly to animals. Just like Liz Houck Kampa of St. Cloud MN, you too can weave rugs from plastic bags. Here are some instructions: https://www.persil.com/uk/dirt-is-good/arts-crafts/plastic-bag-weaving.html

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Science at Home

Hello Families,

Your child is exploring science and engineering in **Sustainable Polymers: Plastics of the Future for a Green, Clean World.**

In this week's lesson, **Materials Matter**, we explored how long chains of molecules that make up polymers and plastics affect the function of an object. We conducted a test to see how heat affects the different types of plastics.

We hope you try one or more of these "Science at Home" activities with your child. You and your child can have fun making discoveries together while practicing science and engineering skills.

Try these "Science at Home" Activities:

- **Share Your Polymer Learning:** Show your family members the different polymers that are around your home – natural polymers like fingernails and jello and synthetic polymers like plastic bottles and carpet.
- **Cup Wars at Home:** Try the Cup Wars experiment at home. Find different types of cups and create a data sheet as you test each one.
- **Cup War Video:** Create a video demonstrating the cup wars experiment and share your observations. Share how each cup is designed of specific materials to meet a desired need.
- **Research Plastics:** Research how plastics are made and what the typical life cycle is of plastics.
- **Plastic Benefits/ Plastic Challenges:** Work with your family to develop a list of plastics you use each day. Describe the benefits of the plastic items and the challenges of the plastic items.
- **Conduct an Experiment:** Compare how quickly organic waste decomposes when wrapped in plastic verses organic waste placed in soil. Observe if the plastic degrades over a set period of time. - https://www.science-sparks.com/easy-decomposition-experiment/

National Science Foundation

NSF Center for Sustainable Polymers

Appendix A

Cup A: Sketch the Appearance BEFORE Heating:

(Include size, shape, texture, hardness, and color)

Make a Prediction:
Can this cup withstand heat? Yes or No.
Why do you think this?

Cup A: Sketch the Appearance AFTER 30 seconds of Heating:

(Include size, shape, texture, hardness, and color)

Make an Observation:
Did the cup withstand heat as you predicted? Why do you think it is or is not designed to withstand heat?

Appendix A
(Continued)

Cup B: Sketch the Appearance BEFORE Heating:

(Include size, shape, texture, hardness, and color)

Make a Prediction:
Can this cup withstand heat? Yes or No.
Why do you think this?

Cup B: Sketch the Appearance AFTER 30 seconds of Heating:

(Include size, shape, texture, hardness, and color)

Make an Observation:
Did the cup withstand heat as you predicted? Why do you think it is or is not designed to withstand heat?

Appendix A
(Continued)

Cup C: Sketch the Appearance BEFORE Heating:

(Include size, shape, texture, hardness, and color)

Make a Prediction:

Can this cup withstand heat? Yes or No. Why do you think this?

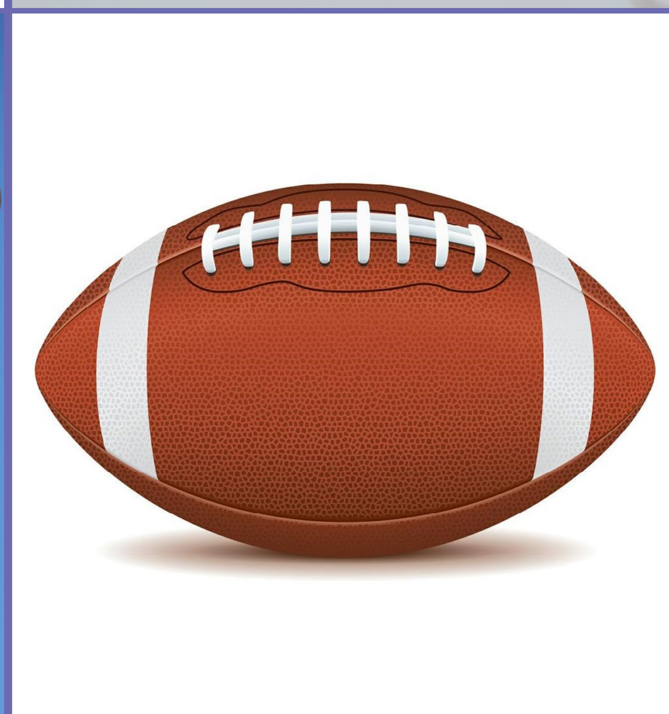
Cup C: Sketch the Appearance AFTER 30 seconds of Heating:

(Include size, shape, texture, hardness, and color)

Make an Observation:

Did the cup withstand heat as you predicted? Why do you think it is or is not designed to withstand heat?

Appendix B



Appendix B
(Continued)

Rubber Band	Bouncy Ball
Football	Parachute

Appendix B
(Continued)

Appendix B

(Continued)

Skateboard	Rubber Car Tire
Plastic Silverware	Hair and Fingernails

Appendix B
(Continued)

Appendix B
(Continued)

Turtle Shell	Tree
DNA	Silly Putty

Appendix C

Container Description Sheet

Aluminum Can

Facts:

- Aluminum is a sustainable metal and is 100% recyclable.
- Nearly 75% of aluminum ever produced is still in use today.
- Energy saved from recycling one ton of aluminum is equivalent to the amount of electricity an average home uses over 10 years.
- There is no limit to the number of times aluminum cans can be recycled.

Brainstorm:

Pros to using aluminum cans:

Cons to using aluminum cans:

Appendix C
(Continued)

Container Description Sheet

Plastic Water Bottle

Facts:

- Plastic takes up to 1,000 years to degrade in a landfill.
- Only about 25% of the plastic produced in the U.S. is recycled.
- Recycling plastic takes 88% less energy than making plastic from raw materials.
- Americans throw away 35 billion plastic bottles every year.

Brainstorm:
Pros to using plastic water bottle:

Cons to using plastic water bottle:

Appendix C
(Continued)

Container Description Sheet

Glass Beverage Bottle

Facts:

- Glass bottles and jars are 100% recyclable and can be recycled endlessly without any loss in purity or quality.
- Glass takes 1,000,000 years to fully degrade in a landfill.
- Recycling glass takes 30% of the energy required to produce glass from raw materials.
- Recycling one glass bottle saves enough energy to light a 100-watt lightbulb for four hours.

Brainstorm:
Pros to using glass beverage bottle:

Cons to using glass beverage bottle:

Appendix C
(Continued)

Container Description Sheet

Reusable Water Bottle

Facts:

- Many different choices for reusable water bottles – glass, plastic, and stainless steel.
- Many types are still recyclable after the product life.
- Using tap water costs less. Water in the US is required to meet Federal water standards.

Brainstorm:
Pros to using a reusable plastic water bottle:

Cons to using a reusable plastic water bottle:

The SciGirls Strategies

Proven Strategies for Engaging Girls in STEM

The **SciGirls** approach is rooted in research about how to engage girls in STEM. A quarter of a century of studies have converged on a set of common strategies that work, and they have become the framework for **SciGirls**. The original set of strategies, created in 2010, were updated in 2019 to reflect current research.

1

Connect STEM experiences to girls' lives.

(Boucheretal.,2017;Sammetetal.,2016;Bonner&Dornerich,2016;Ereteetal.,2016;Stewart-Gardineretal.,2013;Civil,2016;Verdinetal.,2016;Cervantes-Soon,2016).

Make STEM real and meaningful by engaging girls in activities that draw on their interests, knowledge, skills, culture, and lived experiences. This helps girls develop a STEM identity and increases their sense of belonging in STEM.

2

Support girls as they investigate questions and solve problems using STEM practices.

(Buckholz et al., 2014; Kim, 2016; Scott & White, 2013; Farland-Smith, 2016; Munley & Rossiter, 2013; Civil, 2016; Riedinger et al., 2016)

Engage girls in hands-on, inquiry-based STEM experiences that incorporate practices used by STEM professionals. Let girls take ownership of their own STEM learning and engage in meaningful STEM work to positively impact their identities and re-define how they see STEM.

3

Empower girls to embrace struggle, overcome challenges, and increase self-confidence in STEM.

(Blackwell et al., 2007; Dweck, 2000; Halpern et al., 2007; Kim et al., 2007; Mueller & Dweck, 1998)

Help girls focus on and value the process of learning by supporting their strategies for problem solving and letting them know their skills can improve through practice. Support girls to develop a growth mindset—the belief that intelligence can develop with effort and learning.

4

Encourage girls to identify and challenge STEM stereotypes.

(Allenetal.,2017;Carlietal.,2016;Cheryanetal,2015;Robnett,2016;Allenetal.,2017;Carloneetal.,2015;Sammetetal.,2016,Scottetal.,2014;Tanetal.,2013;Dasguptaetal.,2014;Verdin et al., 2016; Civil, 2016; Boucher et al., 2017)

Support girls in pushing against existing stereotypes and the need to conform to gender roles. Helping girls make connections between their unique cultural and social backgrounds and STEM disciplines will negate potential stereotype barriers.

5

Emphasize that STEM is collaborative, social, and community-oriented.

(Capobiancoetal.,2015;Diekmanetal.,2015;Leaper,2015;Riedingeretal.,2016;Robnett,2013;Parker&Rennie,2002;Scantlebury&Baker,2007;Werner&Denner,2009;Cakiretal.,2017; Sammet et al., 2016; Boucher et al., 2017; Clark et al., 2016; Leaper, 2015)

Highlight the social nature of STEM to increase interest and motivation and change the stereotypical perception that STEM jobs require people to work alone. Girls benefit from a supportive environment that offers opportunities to build relationships and form a collective identity.

6

Provide opportunities for girls to interact with and learn from diverse STEM role models.

(Kochetal.,2015;Leaper,2015;Adamsetal.,2014;Jethwanietal.,2017;Kessels,2014;O'Brienetal.,2016;Levineetal.,2015;Hughesetal.,2013;Cheryanetal.,2015;Weisgram&Diekman,2017)

Introduce girls to diverse women role models from varied STEM career pathways to help girls see potential futures and develop resilient STEM identities. Positive role models can increase girls' interests in, positive attitudes toward, and identification with STEM.

Send us your Feedback!

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4hpolymers.org/evaluation

NATIONAL PEER REVIEWED

MODULE

3

GRADES 3-5

Sustainable Polymers

Plastics of the Future for a Green, Clean World

A 4-H STEM Curriculum for Grades 3-5 | 4hpolymers.org

National Science Foundation | NSF Center for Sustainable Polymers

4-H Polymer Science Curriculum for

Grades 3-5

4hpolymers.org

The themes of these modules touch on the prevalence and impact of plastics in everyday life. Plastics are versatile materials that come in different shapes, sizes, and exhibit different material properties. Scientists and engineers are working on new ways to create, use, and recycle plastics, so we can use plastics for their many advantages and lessen their effects on our environment.

Each module will include "Tips for Facilitators" and the Science and Engineering Practices, as well as opportunities to use "I Wonder" Boards. In addition, these modules incorporate the SciGirls Strategies for gender equitable STEM learning. We encourage instructors to collect feedback throughout this module and submit via this evaluation form: **4hpolymers.org/evaluation**.

National Science Foundation
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Tips and Callouts

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These tips provide strategies and helpful suggestions for facilitators.

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These boards should be used to track children's questions and ideas during the lesson for further investigation. This tool promotes experiential learning by youth while encouraging curiosity and discovery. Basic "I Wonder" Boards have "I Wonder..." written at the top of a large sheet or white board.

Science and Engineering Practices

The Next Generation Science Standards (NGSS) identifies eight practices of science and engineering that are essential for all students to learn. Using these practices, youth make sense of phenomena and use these skills to investigate the world and design and build systems.

SciGirls Strategies

SciGirls

Based on educational research, the SciGirls Strategies are used to target and engage girls in STEM learning, but have also been proven to work with all learners, including underrepresented youth. See the SciGirls Strategies handout at the back of the module for a more detailed explanation.

Module 3

Plastics in Your World

Primary Authors: Jessica Bautista, Steven Worker, Emma Simpson, Allie Panero, Abigail Breneisen, Victoria Bain, and Martin Smith

Introduction

MODULE SUMMARY

Youth will be introduced to different kinds of plastics that are used in daily life. Specifically, youth will analyze various plastics by sight, touch, smell, and sound. They will categorize plastics based on the U.S. 1-7 plastic numbering system.

Total lesson time needed for Module 3: 35-55 minutes not including set up time
Getting Ready: 30 minutes total

- Activity A: Sort, Sort, Sort! (15-25 minutes)
- Activity B: Sort by Resin Identification Code (10-15 minutes)
- Reflection/Wrap Up (10-15 minutes)
- Total estimated time for Module 3: 65-85 minutes, including set up time

Module Focus

LEARNING OBJECTIVES	• Youth will discover and identify different types of plastics • Youth will understand that there are different types of plastics with different properties • Youth will understand the Resin Identification Codes, (U.S. plastic numbering system), and its relationship to the materials and their properties
SCIENCE & ENGINEERING PRACTICES *Youth will engage in the following NGSS Practices:*	• Planning and carrying out investigations • Analyzing and interpreting data • Constructing explanations (for science) or designing solutions (for engineering)
CONCEPTS & VOCABULARY	• **Bioplastic**: polymers that come from biomass and are often made from starch-containing plants, such as corn and potatoes. Many of these bioplastics are compostable • **Plastic**: a type of human-made material. Usually made from petroleum or oil (traditional) but plastics can also be made from renewable resources like plants (bioplastic). All plastics consist of polymers • **Polymer**: large molecule made up of chains of small repeating units. Each repeating unit is called a monomer *Continued on next page*

Module Focus (Continued)

CONCEPTS & VOCABULARY

- **Resin Identification Code (RIC)**: a number used to identify plastic based on its composition; in the US, there are 7 resin identification codes which are usually placed within the "recycling symbol" of arrows forming a triangle
- **Starch**: odorless and tasteless white substance made from plants
- **Synthetic**: a material made by chemical means

Facilitator Preparation

MATERIALS

- ☐ Collected plastic (numbered 1-7), at least one of each plastic type per group
- ☐ Self-standing, flat-bottom paper bags (1 per item)
- ☐ Copies of Appendix A: Observation Sheet
- ☐ Copies of Appendix B: Sample Town Guide to Plastic Recycling or your local recycling guide. (check with your local municipal recycling center for their recycling guide)
- ☐ Copies of the local recycling guide
- ☐ Scratch paper
- ☐ Writing utensils
- ☐ Flipchart or whiteboard

GETTING READY (30 MINUTES)

- Collect one of each type of plastic item (e.g., water bottle, yogurt container, Styrofoam, etc.) plastic types (1-7). Note: The most common and easily obtainable plastic numbers types are 1, 2, 4, 5, and 6. Numbers 3 and 7 are more difficult to find, and are not necessary to complete the activity, but can be included as well. Examples of products for each plastic may be found in Appendix B.
- For larger groups, collect 2 of each plastic type and make two sets of bags.
- Label your bags A-G.
- Place 1 plastic item into each bag.
- **Note**: This activity is intended for tactile observations, youth should not look at the item.

Continued on next page

Facilitator Preparation (Continued)

Facilitator Tip
Research your local recycling program before the lesson and bring copies of any recycling guides or resources offered by your local solid waste program. Often local recycling programs have colorful guides with pictures of items that can be recycled.

- Set each bag at different locations around the room
- Note: If choosing to collect two of each plastic type to satisfy needs of a larger group, place two bags at each station
- Make 1 copy of Appendix B per group
- Make 1 copy of Appendix A for each youth.
- Make 1 copy of the local recycling guide per youth
- Consider how you will divide youth into pairs or small groups for the various activities
- Note any safety hazards of items, such as fragile materials or choking hazards
- Provide each pair/small group with scratch paper and writing utensils

Background Information for the Facilitator

Plastics are part of our everyday lives. Plastic is one of the most widely-used materials in society. We find it in everything from drink cups and bags, to chairs and car parts, and from toys to clothing to medical devices. Chemically, plastics are composed of polymers, compounds formed from long, repeating chains of smaller molecules. These long, chain-like molecules tend to form strong, dense, and flexible materials.

Plastics may be divided into two distinct groups: thermoplastics and thermosets. Many plastics are thermoplastic, where they can be heated and reformed repeatedly. This property allows for easier recycling. The other type, thermoset plastics, can not be re-melted after they are initially formed. When initially manufactured, additives may be blended into the plastic to protect the final product from degrading due to sunlight, heat, or bacteria, provide flame retardancy, or change the color and texture.

Plastics can look and feel similar, but can be made from different polymers and have different uses. Some plastics are made from polymers that are **synthetic**, meaning they are created from chemical means. Other plastics are made using natural, biological sources, such as **starch** from plants. These are often called **bioplastics**. For example, cups and cutlery can be made from polymers derived from corn. These products can be biodegradable when using industrial composting methods.

Most plastics have the following properties:

- Resistant to chemicals.
- May be both insulators for electricity and heat (e.g., coffee pot handles, insulated coolers).
- Light in weight with varying degrees of strength.
- May be processed to produce thin fibers or intricate parts.
- Have a nearly limitless range of colors and other inherent properties. Plastics may be made to mimic cotton, silk, wool, porcelain, marble, or aluminum.
- Most plastics are made from petroleum, however, new techniques are becoming available to make plastics from plant-based starch, called bioplastics.

As different types of plastic have different properties, the ways we make, use, dispose of, and recycle them vary. To aid in sorting, the Society of the Plastics Industry, Inc. designed a uniform system to identify various polymer types. The **Resin Identification Code (RIC)** outlines seven numbers to identify seven unique types of plastics based on their composition. One way to tell what types of plastics you encounter is to look for a number inside of a recycling symbol on an item.

In the United States, the numbers range from 1 to 7 and inform us of what type of plastic the product is (Figure 1). Each of the seven types of plastic have different properties that make it suitable for certain applications. For example, (1) PET is a widely produced plastic. It is commonly used in food packaging because it is a barrier to gas and moisture, light, and durable. PET is also known as polyester and used to create fabric and insulation.

It is important to understand that even though a plastic item has a RIC number, it does not mean that a local recycling center will accept that type of plastic. Generally, plastic numbers 1, 2, & 5 are recyclable through local recycling programs. However, plastic numbers 3, 4, 6, & 7 are generally not accepted by local recycling centers.

Most local municipalities have recycling programs with recycling guides to help determine which items are accepted in recycling bins or at local recycling centers, making the process an easy and efficient task. Due to shifts in local, national, and international recycling markets, however, the numbered plastics that are accepted may also change. **Be sure to check your local recycling guide to help determine what plastics can be recycled**.

Figure 1. Resin Identification Code

"I Wonder Board"
While the professional science and engineering communities often require specialized training and tools, anyone can learn to engage in similar processes and practices! Activities encourage "wondering" and emphasize how important it is for adults to model and encourage curiosity in youth. These "wonders" are often turned into questions that can be investigated or studied. Consider posting an "I Wonder" board (see Front Matter for full explanation) to help surface these "wonders" and perhaps provide inspiration for your group to dig deeper into their curiosities.

Activity A

Sort by Plastic Properties (15-25 minutes)

Youth will use their sense of touch to observe a variety of commonly-used plastic items. They will discuss how they are similar and different based on their tactile observations. After observing the different characteristics of the plastics, youth will match their initial observations to the Resin Identification Code (RIC) system to find what types of plastic they have identified.

Facilitator Tip
Be sure to research your local recycling program before the lesson and bring copies of any recycling guides or resources offered by your local solid waste program. Often local recycling programs have colorful guides with pictures of items that can be recycled. You will likely be able to determine which numbered plastics are accepted at local recycling programs. Please use local information to make the activity more relevant to youth and their families.

OPENING QUESTIONS AND PROMPTS

Facilitate a group discussion to get youth thinking about what they know about the main learning objectives of the module. 1 You may ask the following prompts. There is overlap in some questions between modules so you may want to develop new broad, open-ended questions for your group, if needed. Use the flip chart paper or a whiteboard to draw or write responses to the prompts:

- Explain where you find plastics in your daily life.
- Explain what you know about different types of plastic and their uses.
- Discuss what you know about your local recycling program.

1 SciGirls
Connect STEM experiences to lives

PROCEDURE (EXPERIENCING)

Pass out one observation sheet per youth (Appendix A). Explain how to fill out the observation sheet.

1. Divide youth into groups 5 so that there is one group per station. Have the groups go to a station.
2. Instruct the youth to reach their hand into the bags, without looking inside, and use their sense of touch to feel the object. The youth should use descriptive terms to explain the plastic item after touching and feeling the object.

Facilitator Tip
Youth may just say what they think the object is (for example: plastic water bottle or yogurt cup). Prompt them to describe the object's properties (the way the object feels). Descriptors can include: hard or soft, flexible or rigid, thick or thin, heavy or light, smooth or rough, shape, and other descriptors.

3. Have the youth record their observations on their Observation Sheet (Appendix A). 2
4. After all the youth have had a chance to feel the plastic object and record observations at their station, have them rotate to the next station in an orderly fashion (for example: clockwise or counterclockwise).
5. Youth should repeat steps 3-5 until all the youth have been to every station and recorded detailed observations of all the different plastic types.
6. After going to each station, have youth meet in their groups.
7. Using their observation sheet, have the groups develop a sorting system for the different plastic items. They may choose any sorting system they want (for example: weight, feel, hardness, strength, thickness, or flexibility).
8. Have youth record their sorting system on the back of their observation sheets (Appendix A). Note that youth have used the Practice of 'Analyzing and Interpreting Data.'
9. As a final part of the activity, ask students to sort items by which plastic items they think can be recycled. Ask them to explain their rationale. Record on Observation Sheet (Appendix A).

2 SciGirls

Support as they investigate using STEM practices

5 SciGirls

STEM is collaborative, social, and community-oriented

SHARE/PROCESS/GENERALIZE

Help guide youth as they question, share, and compare their observations. [2] You may choose one of the questions below as a prompt. If necessary, use more targeted questions as prompts to get to particular points. Remember these questions are not about getting one right answer. [3]

- Explain the similarities and differences you observed between the plastics.
- Discuss some common properties of the different plastics.
- Which plastics did your group identify as recyclable? What do you think makes them recyclable?

Science and Engineering
Note that youth are using the Practice of 'Constructing Explanations.'

2 SciGirls

Support as they investigate using STEM practices

3 SciGirls

Embrace struggle, overcome challenges, and increase self-confidence in STEM

Activity B

Sort by Resin Identification Code (10-15 minutes)

OPENING QUESTIONS AND PROMPTS

Facilitate a group discussion to get youth thinking about what they know about the main learning objectives of the module. 1 You may ask the following prompts. There is overlap in some questions between modules so you may want to develop new broad, open-ended questions for your group, if needed.

- Describe what you know about different kinds of plastics.

PROCEDURE (EXPERIENCING)

1. As a facilitator, introduce the Resin Identification Code, a sorting system for plastics based on the type of polymer used to make that plastic. This code identifies seven types of plastics depending on their composition; you can find this number on the bottom of the object. Handout the Appendix B: Sample Town Guide to Plastic Recycling or your local recycling guide. The Sample Town Guide represents the most common way recycling programs accept or don't accept plastics (1, 2, & 5 generally accepted and 3, 4, 6 & 7 generally not accepted). Share with students the numbered plastics that your local recycling program may accept, if known.

2. Prompt youth to utilize the Sample Town Guide to Plastic Recycling handout (Appendix B) or use your local recycling guide, to assist in identifying what plastic product the item came from.

3. With the help of their observation sheet, have youth guess which plastic type the object was at each station.

4. Have the facilitator pass out a paper bag to each group.

5. Ask youth to identify the Resin Identification Code on each plastic item. Have them compare the findings to their predicted sorting system from Activity A, Part 1.

1 SciGirls

Connect STEM experiences to lives

SHARE/PROCESS/GENERALIZE

Help guide youth as they question, share, and compare their observations. 2 You may choose one of the questions below as a prompt. If necessary, use more targeted questions as prompts to get to particular points. Remember these questions are not about getting one right answer. 3

- In what ways are the plastics in each of the Resin Identification Code numbers similar?
- In what ways are the plastics in each of the Resin Identification Code numbers different ?
- Explain how you think the scientists created their sorting system.
- Note: At this point, make sure the youth understand the prevalence of plastics/recyclable materials that surround us and how they differ.

2 SciGirls

Support as they investigate using STEM practices

3 SciGirls

Embrace struggle, overcome challenges, and increase self-confidence in STEM

Ensure Concept Understanding

At this point, it is important to ensure that the terms **bioplastic**, **plastics**, **polymer**, **resin identification code (RIC)**, **starch**, and **synthetic** have been discovered by or introduced to the youth. The goal is to have the youth discover terms and concepts on their own, defining them with their own words. After youth have stated and shared their understanding of the concepts, then you may introduce the terminology used by scientists to refer to the concepts. Facilitate a brief conversation on the importance of the concepts.

SCIENCE & ENGINEERING IN EVERYDAY LIFE - CONCEPT APPLICATION

Facilitator Tip
When engaging youth in hands-on activities, the process of inquiry serves as a strategy for learning new concept knowledge and skills; however, it is the application of new knowledge or skills to independent, real-world situations that is the final, critical factor in the learning process. Thus, to complete the cycle of experiential learning it is important to be intentional in providing youth specific opportunities for authentic applications.

REFLECTION

Reflecting on experience is an essential part of learning and "making meaning of" an experience. Now is an opportunity to bring the youth together and discuss the things they experienced throughout the module. You may want to use a "circle share" process to facilitate this discussion. Have youth sit in a circle with you. Some general questions you can ask the youth include:

- What is something that you tried that you have never done before?
- What is something new you learned from the activities today?
- How were you a scientist or engineer today?
- Which of the eight practices of science and engineering did you use today?

EXTEND THE LEARNING

- **Science at Home** - These are possible extension activities that can be used with youth as time/interest allows. If you meet multiple times, you might invite youth to do a take home activity and have them report back or bring in an item as described. This helps support application of the concepts you've explored in this module. These activities are also shared on the **Science at Home** handout.

Facilitator Tip
Science at Home can be copied and sent home with the youth, or emailed. It includes a brief summary of the module and provides several activity ideas. It encourages families to engage in science learning together, supporting application of the concepts.

- **Service Learning in Action** - Planning and carrying out a **service-learning** project can be an exciting opportunity for youth to apply their learning as they work to address local and world needs. In Module 6: Service Learning, youth will dive deep into the experiential process by creating and carrying out a service project related to plastics. Below are some suggested activities and real-world service-learning examples that you can explore with your students related to plastics in our world.

- **Real-World Example** - Prisk Elementary students from the Long Beach Unified School District worked with Grades of Green, a local organization, to create a trash-free lunch campaign. They provided specific ways students could bring trash-free lunches and helped increase awareness around the school's waste sorting system at lunch. They even had a school assembly to share their efforts. Check out their efforts at: https://www.gradesofgreen.org/prisk-elementary-green-team-students-lead-waste-reduction-efforts/

SERVICE IDEAS

- Know What To Recycle Campaign - Knowing which plastics items can be recycled can sometimes be a daunting task. What might be recyclable in one community could be trash in another. Investigate what plastics are recyclable in your community by researching your county or local municipality's website. Then create a recycling campaign at your school or in your community. Use your knowledge of the Resin Identification Code as you investigate which plastics are recyclable. http://apps.npr.org/plastics-recycling/
- Reduce School Lunch Waste - School lunches produce a lot of waste. Much of that waste is single-use plastic items like plastic baggies, plastic bottles, plastic silverware, plastic containers, and plastic packaging. You can start a waste-free lunch initiative at your school and involve other students. Check out these planning and implementation resources from the US Environmental Protection Agency - https://www.epa.gov/students/pack-waste-free-lunch. Ask students to identify one single-use plastic item they will pledge not to use in their school lunches. You can also ask your school to use reusable plastic trays and reusable silverware instead of plastic.

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Science at Home

Hello Families,

Your child is exploring science and engineering in **Sustainable Polymers: Plastics of the Future for a Green, Clean World**.

In this week's lesson, **Plastics In Your World**, we explored and analyzed different kinds of plastics that are used in daily life using observation skills of sight, touch, smell, and amount. We then categorized plastics based on the U.S. 1-7 plastic numbering system.

Here are some "Science at Home" activities to try with your child. This supports your child in practicing science and engineering skills while you have fun together making new discoveries.

Try these "Science at Home" Activities:

- **Discuss Learning**: Ask what your student recorded on their Plastics Observation sheet and how might they apply what they learned from the activity at home.
- **Take a Plastic Treasure Hunt**: Use the Plastic Treasure Hunt Take-Home Chart at home with your student to;
  - Identify plastics in your home and record what the plastic is (e.g. toy, shampoo, utensils) and the number found on the plastic.
  - Record your findings on the take-home observation sheet.
  - Discuss the most common plastic number and what kind of plastics were in that group.
  - Discuss the least common plastic number and what kind of plastics were in that group.
- **Learn About Recycling Options**: Research the nearest recycling facility and discover which types of plastics can be recycled locally. Request a local item recycling chart.
- **Make Smart Disposal Choices**: Hang the Plastic Treasure Hunt Take-Home Chart or local recycling chart in your kitchen. Utilize this chart each day to help you make smart disposal choices.

Watch the the video The Big Sort to see what happens in a recycling center.
https://thekidshouldseethis.com/post/the-big-sort-an-insiders-tour-of-a-recycling-plant

Become inspired to create art from plastics by watching the video, Washed Ashore, Art to Save the Sea. - https://thekidshouldseethis.com/post/washed-ashore-giant-animal-sculptures-made-of-found-beach-plastic

Appendix A

Observation Sheet

Use your sense of touch to observe plastic objects (what the object feels like). Descriptors can include: hard or soft, flexible or rigid, thick or thin, heavy or light, smooth or rough, shape, and other descriptors.

ITEM	OBSERVATIONS
ITEM A	
ITEM B	
ITEM C	
ITEM D	
ITEM E	
ITEM F	
ITEM G	

Appendix B

Sample Town Guide to Plastic Recycling

Make copies and provide 1 copy per group or provide a copy of your local recycling guide for students to use.

Recycling Center Accepts:

Recycling Center does NOT Accept:

Recycling Center Accepts:

Recycling Center does NOT Accept:

Send us your Feedback!

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4hpolymers.org/evaluation

NATIONAL
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MODULE
4
GRADES 3-5

4-H Polymers

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National Science Foundation

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Module 4

Plastics in Our World

Primary Authors: Taylor Gullikson, Emma Simpson, Allie Panero, Jessica Bautista, Steven Worker, and Martin Smith

Introduction

MODULE SUMMARY

In this module, youth will explore the many ways in which they encounter plastics in their daily lives and consider some of the challenges our world faces with the global prevalence of plastic. Working in teams they will discover and evaluate disposal options for plastics such as recycling, landfill, reuse, repurpose, and industrial composting. Youth will identify ways to reduce waste by choosing to refuse single use plastics and create an upcycled item of their own design.

Total lesson time needed for Module 4: 70-100 minutes not including set up time
Getting Ready: 20-35 minutes total

- Activity A: Where Does All of the Plastic Go? (30-40 minutes)
- Activity B: Upcycled Plastic Bottles (30-45 minutes)
- Reflection/Wrap Up (10-15 minutes)

Total estimated time for Module 4: 90-135 minutes, including set up time

Module Focus

LEARNING OBJECTIVES	• Youth will discover how plastics can be made from different polymers • Youth will evaluate different disposal options for plastics • Youth will identify ways to reduce plastic waste • Youth will design their own repurposed object
SCIENCE & ENGINEERING PRACTICES *Youth will engage in the following NGSS Practices:*	• Asking questions (for science) and defining problems (for engineering) • Obtaining, evaluating, and communicating information
CONCEPTS & VOCABULARY	• **Bacteria**: microscopic living organisms that help with decomposition • **Biodegrade**: a substance or object that can be decomposed by bacteria or other living organisms • **Bioplastic**: polymers often made from starch-containing plants, such as corn and potatoes. Many of these bioplastics are compostable *Continued on next page*

Module Focus (Continued)

CONCEPTS & VOCABULARY

- **Degrade**: matter breaks down into smaller parts by a chemical process
- **Industrial compost**: a site where organic waste products go through a multi-step process converting items into usable soil
- **Landfill**: a site where waste from the community is taken. Clay or soil is used to isolate waste from reaching water systems.
- **Litter**: waste items not properly disposed of in recycling, compost or trash receptacles; are instead left on the ground or in lakes/rivers/ponds
- **Non-renewable resource**: a resource that is only available in limited quantities and takes a long time to be replenished (for example, millions of years)
- **Petroleum**: oil extracted from the earth that can be used for fuel or made into plastic
- **Pollution**: contamination by waste, chemicals, or other substances harmful to the environment
- **Recycle**: to collect and process materials that would otherwise be thrown away as trash and turn them into new products
- **Reduce**: to limit the amount of plastic used in daily life
- **Refuse**: to say no to purchasing or using specific products with plastics, often single use plastics
- **Repurpose**: to use an object for a new purpose other than it was originally intended
- **Reuse**: to use an object again for the same purpose it was originally intended
- **Single use**: to use a plastic item once and dispose after intended use

Facilitator Preparation

MATERIALS-ACTIVITY A ROUND 1

- ☐ Appendices A-E (instructions are found on each page)
- ☐ 4 small paper bags
- ☐ Pencils

GETTING READY (10-15 MINUTES)

- Make copies of Appendices:
- Appendix B: Station Names - 1 copy of each, print and cut
- Appendix C: Item Cards - 1 set
- Appendix D: Recycling Center Reference Sheet - II copies, cut in half, and place one at Stations A-D
- Appendix E: Disposal Options Sheet - 1 copy at each station A-D. This activity can be done either indoors or outside
- Appendix F: Repurpose Template - print as many as needed for your group
- This activity requires 6 stations with flat surfaces (for example tables). Setup stations on flat surfaces and with enough room to help children move around freely. See Appendix A on how to organize the space
- Follow the directions on each appendix page to set up the rest of the activity
- Consider how you will divide youth into smaller groups for the various activities 5

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Facilitator Preparation (Continued)

MATERIALS- ACTIVITY A ROUND 2

- [ ] Same materials as Round 1
- [ ] Appendices A-E (copies from Round 1)
- [ ] 4 small paper bags
- [ ] Pencils

GETTING READY (5-10 MINUTES)

- This activity can be done either indoors or outside.
- This activity requires 9 stations with flat surfaces (for example tables) (3 additional stations need to be added from set up for Round 1)
- Follow the directions on each appendix page to set up the rest of the activity
- Consider how you will divide youth into smaller groups

MATERIALS- ACTIVITY B

- [ ] Plastic bottles with caps (1 for each person)
- [ ] Scissors
- [ ] Potting soil
- [ ] Herb or flower seedlings

GETTING READY (5-10 MINUTES)

- Collect plastic bottles, enough for every young person (or 1 per pair)
- Collect herb or flower seedlings
- Consider how you will divide youth into smaller groups for the various activities

Background Information for the Facilitator

Nearly everyone uses plastics. From food containers and furniture to toys or computers, plastics are a constant in our lives. These plastics are usually made from **petroleum (oil)**, a non-renewable resource. Petroleum is extracted from underground and refined into a variety of substances, including gasoline, jet fuel, and a variety of other products. Petroleum is a valuable resource for our economy. There are, however, potential detrimental side effects for animals, humans, and the environment from plastic waste, oil spills, and increasing the amount of carbon in the air.

Typical plastic materials from petroleum do not easily decompose in the environment like other materials. **Biodegradation** is typically accomplished by **bacteria**, tiny organisms that "eat" and breakdown materials. Most bacteria are not capable of breaking down petroleum-based plastics. Petroleum-based plastics can **degrade** upon exposure to sunlight, but typically not from bacteria. This means that plastics can take hundreds to thousands of years to degrade, especially when buried underneath other trash in **landfills** out of view from sunlight. Plastic trash that does not make it to landfills often ends up as **litter** (pollution) in the environment. Plastic pollution can have detrimental effects on the environment, as plastic debris can injure or poison wildlife, disrupt habitats, and pollute groundwater, rivers, and lakes. Plastics in the environment that breakdown from sunlight can release harmful chemicals that may find their way to water sources as they degrade. For both animals and humans, this type of pollution can result in illness.

Some plastic materials are intended for a **single use**. Once a plastic object has served its purpose, it must be disposed of in a responsible manner. There are multiple approaches to reducing the impacts of petroleum-based plastics. We can reduce our dependence on petroleum-based plastics by **refusing, recycling, reusing, repurposing,** as well as choosing plastics made from renewable resources. One approach is to refuse to purchase single use plastics, including straws, bags, and bottles, thus significantly decreasing excess plastic waste. Another best practice is to choose **reusable** items rather than single-use plastics. By choosing to reduce use of **single-use** plastics (or **refuse** to use), consumers can reduce the amount of raw materials and energy needed to produce plastics, as well as the amount of plastics in landfills.

Finding the most responsible disposal choice for plastics can be tricky. While a lot of plastics are recyclable, certain plastics are not. Identifying an item's plastic number (known as the Resin Identification Code - RIC) helps determine whether a specific plastic item can be recycled or not.

The RIC system was developed by The Society of the Plastics Industry. This code indicates the composition of the plastic. Consulting recycling center websites and paying attention to the numbers on plastic items can help people make the best choices for themselves and the earth. Although the United States does not have a national recycling program, some states have passed deposit laws on beverage containers to promote reuse and recycle. By understanding which plastics are easiest to recycle, consumers can make informed product choices to help decrease the amount of plastics in landfills. In addition, consider if there are alternatives to purchasing petroleum-based plastic items that cannot be recycled, re-used, or composted (generally numbers 3, 4, 6 & 7).

Another approach is to use bioplastics. **Bioplastics** are alternatives to petroleum plastics. They are generally made from renewable resources that can degrade through natural processes. Polylactic acid (PLA, labelled #7) is a plastic made from plant-based materials like corn and sugar. This product can be disposed of in an **industrial compost system** where it will biodegrade within 180 days (as compared to petroleum based plastics that take 1,000 or more years to degrade).

The research being conducted at the Center for Sustainable Polymers seeks to transform how plastics are made, unmade, and remade. The challenge of sustainability is to meet human needs while preserving the earth's life support systems. Sustainable polymers or green materials can be durable and degradable, can be used in applications from adhesives to packaging to building materials, and can be produced efficiently and economically with low environmental impact.

Polymer science is constantly evolving. For information on the petroleum-based plastic life cycle and bioplastics, please visit the University of Minnesota Center for Sustainable Polymers website at https://csp.umn.edu/sustainable-polymers-101/.

Facilitator Tip

Youth may have seen or read recent reports on the plastic pollution crisis impacting our world, including the death of birds, turtles, and other marine mammals caused by plastic trash, especially in our oceans. National Geographic's ***Plastic or Plant*** series offers many articles and videos that highlight the global plastic waste crisis. https://www.nationalgeographic.com/environment/planetorplastic/planetorplasticLGV1/ You can use these resources as well as resources in the Extend the Learning section as you engage youth in learning about plastics in our world.

Activity A

Where Does All of the Plastic Go? (30-40 minutes)

Youth will simulate plastic disposal options in two rounds. In the first round, they will have a limited choice as to how their plastic items are disposed of. In the second round, youth will use what they learned from the first round and make decisions on disposal options, to include recycling, landfill, reuse, repurpose, refuse, and industrial composting.

ROUND 1 (15-20 minutes)

During round 1 of this sorting activity, youth will identify plastics based on their RIC code and determine responsible ways to dispose of them either by choosing to recycle a plastic item or dispose of it in a landfill.

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OPENING QUESTIONS AND PROMPTS

Facilitate a group discussion to get youth thinking about what they know about the main learning objectives of the module. 1 You may ask the following prompts. There is overlap in some questions between modules so you may want to develop new broad, open-ended questions for your group, if needed.

- Explain ways you use plastic in your life.
- Describe how you think plastics might be beneficial.
- Describe how you think plastics might be harmful.
- Describe what you know about different ways one can dispose of plastics.
- Discuss ways you might dispose of or reuse the different products in order to decrease their impact on the environment.
- Discuss how you believe the choices you make in how you dispose of plastics might impact the environment. 5

PROCEDURE (EXPERIENCING)

1. Divide youth into pairs (if there are odd numbers, a group of three is fine). To start the activity, evenly assign each pair to one of the stations A-D. Refer to Appendix A, Activity A round 1 for station set up. 5
2. Each pair will start at one station A-D (this is their "home base"). Each pair will select one Item Card at random from the paper bag. Then they will consult the Disposal Reference Sheet (Appendix D) to determine what happens to their item. They will then walk to the appropriate disposal table (either Landfill or Recycle) as indicated by their discovery to dispose of their item.
3. After proceeding to either Landfill or Recycle, youth will go back to their original station and repeat this process once or twice more (up to the teacher's discretion).

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SHARE/PROCESS/GENERALIZE

Help guide youth as they question, share, and compare their observations. You may choose one of the questions below as a prompt. If necessary, use more targeted questions as prompts to get to particular points. Remember these questions are not about getting one right answer.

- After the youth have disposed of at least three items, bring the group back together to share what they've learned about disposal of materials. As a large group, investigate what materials were placed in the landfill and recycling bags. Make notes on a piece of paper or take a picture to compare changes with Activity B.
- Identify the items you picked.
- Describe any thoughts or feelings you had when you disposed of your items.
- If you can't recycle a plastic object and you choose not to throw it into a landfill, describe what you could do with the object.

Facilitator Tip
Youth can consider different repurposing options. You might show pictures or examples of items that have been repurposed. You might find a book on recycled crafts, such as *Upcycled Accessories: 25 Projects Using Repurposed Plastic* by Tracie Lampe. Or bring upcycled items of your own to share as examples.

After large group discussion, youth will return to their starting stations (A-D).

ROUND 2 (15-20 minutes)

This activity expands on the previous activity by introducing composting, reuse/repurpose, and refuse as disposal options. To reset for round 2, collect the used Item Cards and replace cards in each paper bag at the starting stations. Refer to Appendix A, Activity A, Round 2 for station setup.

PROCEDURE (EXPERIENCING)

Back at their original stations in their same pairs, youth will again pick an Item Card at random.

1. Youth can choose to dispose of their item in the Landfill, Recycling, Industrial Compost, or to Reuse/Repurpose/Refuse the item. They will reference the Disposal Options Sheet Appendix E at their starting stations in addition to the Recycling Center Reference Sheet Appendix D.
2. If they chose to reuse or repurpose the item, youth will go to that station. They will be prompted with the Reuse Template to write or draw their ideas.
3. Youth can choose to refuse to use the item on their card. They would go to the Refuse station.
4. Youth will go through this process one or two more times (up to the discretion of the facilitator).

SHARE/PROCESS/GENERALIZE

Help guide youth as they question, share, and compare their observations. **2** You may choose one of the questions below as a prompt. If necessary, use more targeted questions as prompts to get to particular points. Remember these questions are not about getting one right answer.

- Explain how you would compare your material disposal choices in Round 2 to results from Round 1 (notes or picture).
- Describe what, if anything, was different about your process in Round 2?
- Describe how you identified how to dispose of an item.
- Describe how you identified items to reuse or refuse to use. How might you reuse an item? If you refused an item, what alternatives might you choose instead?
- Explain how you helped care for the environment with your disposal choices.

Science and Engineering Practices
Note that youth are engaging in the Science and Engineering Practice of Obtaining, evaluating, and communicating information.

Facilitator Tip
See if youth applied new knowledge or skills based on their understanding of the properties of plastics.

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"I Wonder Board"
While the professional science and engineering communities often require specialized training and tools, anyone can learn to engage in similar processes and practices! Activities encourage "wondering" and emphasize how important it is for adults to model and encourage curiosity in youth. 2 These "wonders" are often turned into questions that can be investigated or studied. Consider posting a "I Wonder" board (see Front Matter for full explanation) to help surface these "wonders" and perhaps provide inspiration for your group to dig deeper into their curiosities.

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Activity B

Upcycled Plastic Bottles (30-45 minutes)

Youth will upcycle plastic bottles destined for disposal and create a mini garden pot. Upcycling is a way of reusing items and turning items that would otherwise be unused into functional and useful things.

OPENING QUESTIONS AND PROMPTS

Facilitate a group discussion to get youth thinking about what they know about the main learning objectives of the module. 1 You may ask the following prompts. There is overlap in some questions between modules so you may want to develop new broad, open-ended questions for your group, if needed.

- Explain what you know about reusing or repurposing.
- Describe how you have seen items made into something new instead of being thrown away.

PROCEDURE (EXPERIENCING)

1. Provide the engineering design challenge to youth:

   You are tasked with upcycling a plastic bottle destined for either the landfill or recycling center and making something new to grow a plant!

Facilitator Tip
Youth may have many creative ideas on how to upcycle a plastic bottle. You may want to offer a more open-ended design challenge. Adapt the steps below to fit your own challenge. For upcycle ideas, please see the Extend the Learning section.

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2. Allow youth time to think about, design, and sketch their ideas for creating a planter using the supplies provided. Show the supplies available: (a) plastic bottles, (b) scissors, (c) fabric, (d) rubber bands, and (e) tape. Provide youth with room to be creative in their designs; there is no one right answer.

3. Let youth build their planters or other designs. Allow youth to make and create and give them space for creativity.

4. Once youth are finished, allow them to fill their planters with potting soil and plant a seedling. Let youth add some water to their planter.

5. Invite youth to share their finished product, explain why they made design decisions the way they did, explain any challenges they encountered and how they overcame them. Note that youth have engaged in the Science and Engineering Practice of 'Asking questions and defining problems' throughout this activity.

Facilitator Tip
Consider having an "Upcycled" Showcase in which youth share their upcycled bottles with family or other community members.

SHARE/PROCESS/GENERALIZE

Help guide youth as they question, share, and compare their observations. **2** You may choose one of the questions below as a prompt. If necessary, use more targeted questions as prompts to get to particular points. Remember these questions are not about getting one right answer.

- Describe what you did with the plastic bottle destined for disposal.
- Describe other ways you might upcycle items that would otherwise be thrown away.
- Explain why you think some items might be upcycled more easily than others.

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Ensure Concept Understanding

At this point, it is important to ensure that the terms **bioplastic, degrade, industrial compost, landfill, litter, non-renewable resource, petroleum, pollution, recycle, repurpose, and reuse** have been discovered by or introduced to the youth. The goal is to have the youth discover terms and concepts on their own, defining them with their own words. After youth have stated and shared their understanding of the concepts, then you may introduce the terminology used by scientists to refer to the concepts. Facilitate a brief conversation on the importance of the concepts.

SCIENCE & ENGINEERING IN EVERYDAY LIFE - CONCEPT APPLICATION

Facilitator Tip
When engaging youth in hands-on activities, the process of inquiry serves as a strategy for learning new concept knowledge and skills; however, it is the application of new knowledge or skills to independent, real-world situations that is the final, critical factor in the learning process. Thus, to complete the cycle of experiential learning it is important to be intentional in providing youth specific opportunities for authentic applications.

REFLECTION

Reflecting on experience is an essential part of learning and "making meaning of" an experience. Now is an opportunity to bring the youth together and discuss the things they experienced throughout the module. You may want to use a "circle share" process to facilitate this discussion. Have youth sit in a circle with you. Some general questions you can ask the youth include:

- Did you try something that you've never done before?
- What is something new you learned from the activities today?
- How were you a scientist or engineer today?
- Which of the eight practices of science and engineering did you use today?

EXTEND THE LEARNING

- **Science at Home -** These are possible extension activities that can be used with youth as time/interest allows. If you meet multiple times, you might invite youth to do a take home activity and have them report back or bring in an item as described. This helps support application of the concepts you've explored in this module. These activities are also shared on the Science at Home handout.

Facilitator Tip
Science at Home can be copied and sent home with the youth, or emailed. It includes a brief summary of the module and provides several activity ideas. It encourages families to engage in science learning together, supporting application of the concepts.

- **Service Learning in Action -** Planning and carrying out a service-learning project can be an exciting opportunity for youth to apply their learning as they work to address local and world needs. In Module 6: Service Learning, youth will dive deep into the experiential process by creating and carrying out a service project related to plastics. Below are some suggested activities and real-world service-learning examples that you can explore with your students related to plastics in our world.

- **Real-World Examples -** Junior high school student, Alex Weber saw a major problem as she was free diving off the coast of California; thousands of golf balls lined the ocean floor from a nearby golf course. Alex and her dad teamed up with a postdoctoral student at Stanford University to conduct a research project on the harmful effects of golf ball plastic pollution. As a result, the coastal golf course is working to keep harmful golf balls out of the ocean. To read more about Alex's effort, please visit https://www.theplasticpick-up.org/

  Students at Meadowbrook Elementary in Hopkins, MN wanted to share the message of recycling with other students. They organized a playground litter clean-up and created posters on how to recycle commonly found items, like plastic bottles. They were featured on the school's video announcements, Goodmorning Meadowbrook.

SERVICE IDEAS

- **Establish a Recycling Program in Your School** - Form a team of fellow students who want to create a recycling plan for your school. First, determine the greatest area of need; do you need recycling bins at your school, do you need better awareness of what is put in recycling bins, or do students need to help sort recyclables during the lunch period. Then come up with a strategy to address the need. Create an awareness campaign and use student news, posters, presentations, and public announcements to get the word out to other students. Ask teachers for support.
- **Plastic Free Schools** - Join the Plastic Free Schools community and follow the steps outlined to reduce the amount of plastic waste created by your school. https://www.plasticpollutioncoalition.org/guides-schools

SOURCES

Anderson, D., Farah, S., & Langer R. (2016). Physical and Mechanical Properties of PLA, and Their Widespread Applications - A Comprehensive Review. *Advanced Drug Delivery Reviews, 107*, 367-392.

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Plastic Pollution Coalition [Website]. (2020). *What is 'Plastic Free Schools?'*. https://www.plasticpollutioncoalition.org/guides-schools

The Plastic Pick-Up [Website]. (n.d.). *Discovering new sources of marine plastic pollution.* https://www.theplasticpick-up.org/

Science at Home

Hello Families,

Your child is exploring science and engineering in **Sustainable Polymers: Plastics of the Future for a Green, Clean World**. We hope you will try these "Science at Home" activities at home.

In this week's lesson, **Plastics in Our World**, we discovered the many ways in which we encounter plastics in our daily lives. We developed design solutions to reduce the impacts that plastic use has on the environment.

Try these "Science at Home" Activities:

- **Get Creative About Upcycling**: Find a single use object at home, in your lunch, or in a store (such as plastic shopping bag, straws, juice pouches, paper napkins, plastic cup, baggies, paper towel, etc.). Then create a re-usable version of this object or make a new object. Here are some ideas to get you started: https://www.budgetdumpster.com/blog/diy-plastic-bottles-recycling/.
- **Upcycle Your Old T-Shirts**: Make a reusable cloth bag to use instead of plastic bags. Find directions - https://www.instructables.com/id/No-Sew-T-Shirt-Tote-Bag-1/. Make a plan for how you will use this bag at a store where you normally get plastic bags.
- **Eliminate Single Lunchtime Plastic Waste**: Work with your class or friends at school to each identify one single-use plastic lunchbox item you can replace with a reusable item. Track how much waste you personally reduced each day and how much waste you collectively reduced each day.
- **Reduce Single Use Plastic**: Identify three ways that you or your family could reduce your use of single-use plastics, such as shopping bags, take-out food containers, or grocery items.

Science at Home

(Continued)

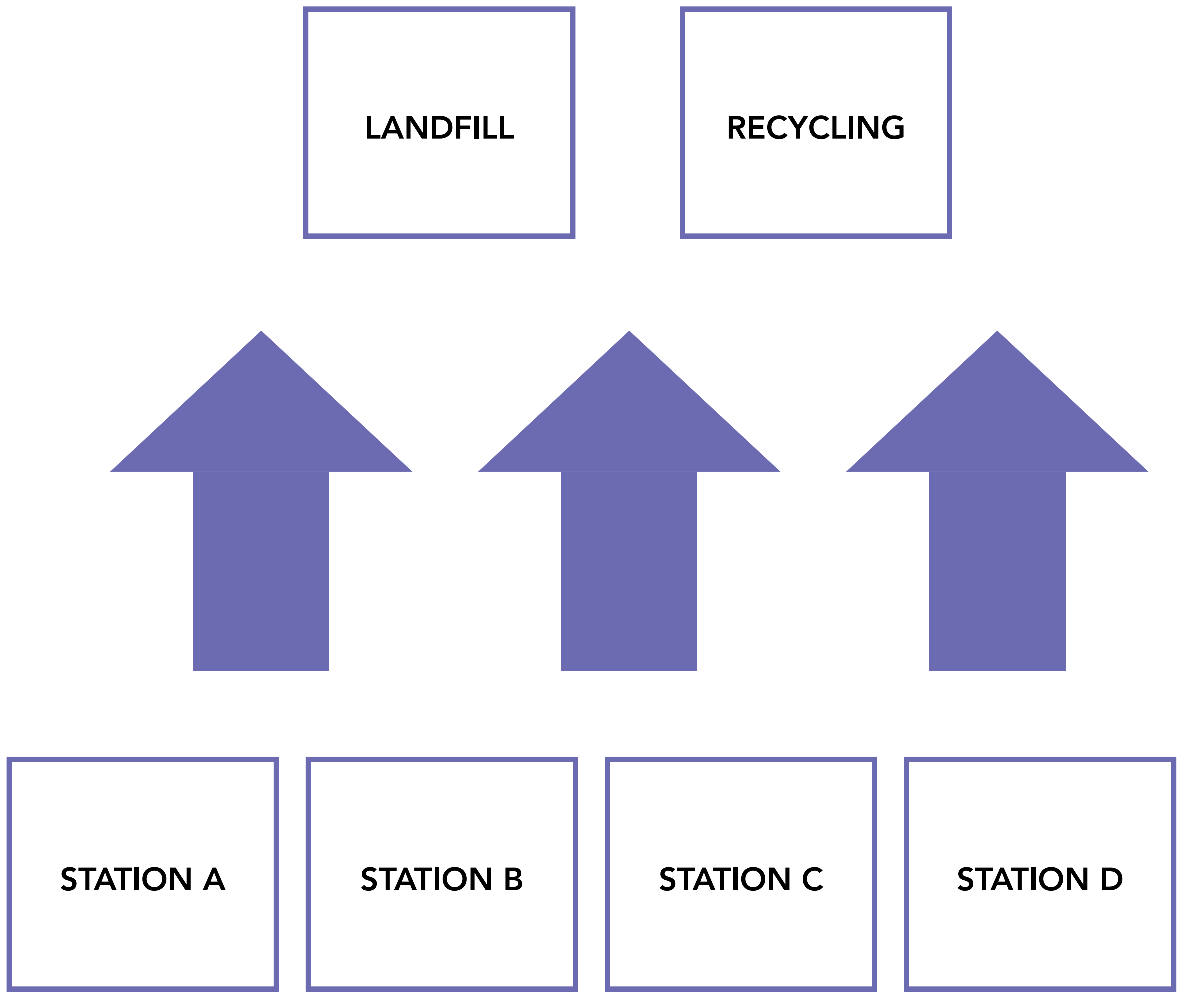
- **Watch a Video and Discuss How to Reduce Plastic**: Learn about plastics by watching one of the following videos and discuss how to reduce plastic consumption:
  - **How We Can Keep Plastics Out of Our Ocean, National Geographic**
    https://youtu.be/HQTUWK7CM-Y
  - **Kids Take Action Against Ocean Plastic Short Film Showcase**
    https://youtu.be/hKFV9IquMXA
  - **How Industrial Composting works**
    https://youtu.be/s_27lJ3NQO4
- **Play a Game**: Challenge your recycling knowledge by playing the following games on sorting recyclable materials:
  - **Recycle Roundup- Game**
    http://images.nationalgeographic.com/wpf/media-content/richmedia/1/1143/project/dist/desktop.html
  - **Recycle City Challenge- Game**
    https://www3.epa.gov/recyclecity/challenge/

National Science Foundation

NSF Center for Sustainable Polymers

Appendix A

Activity Set Up - Activity A, Round 1



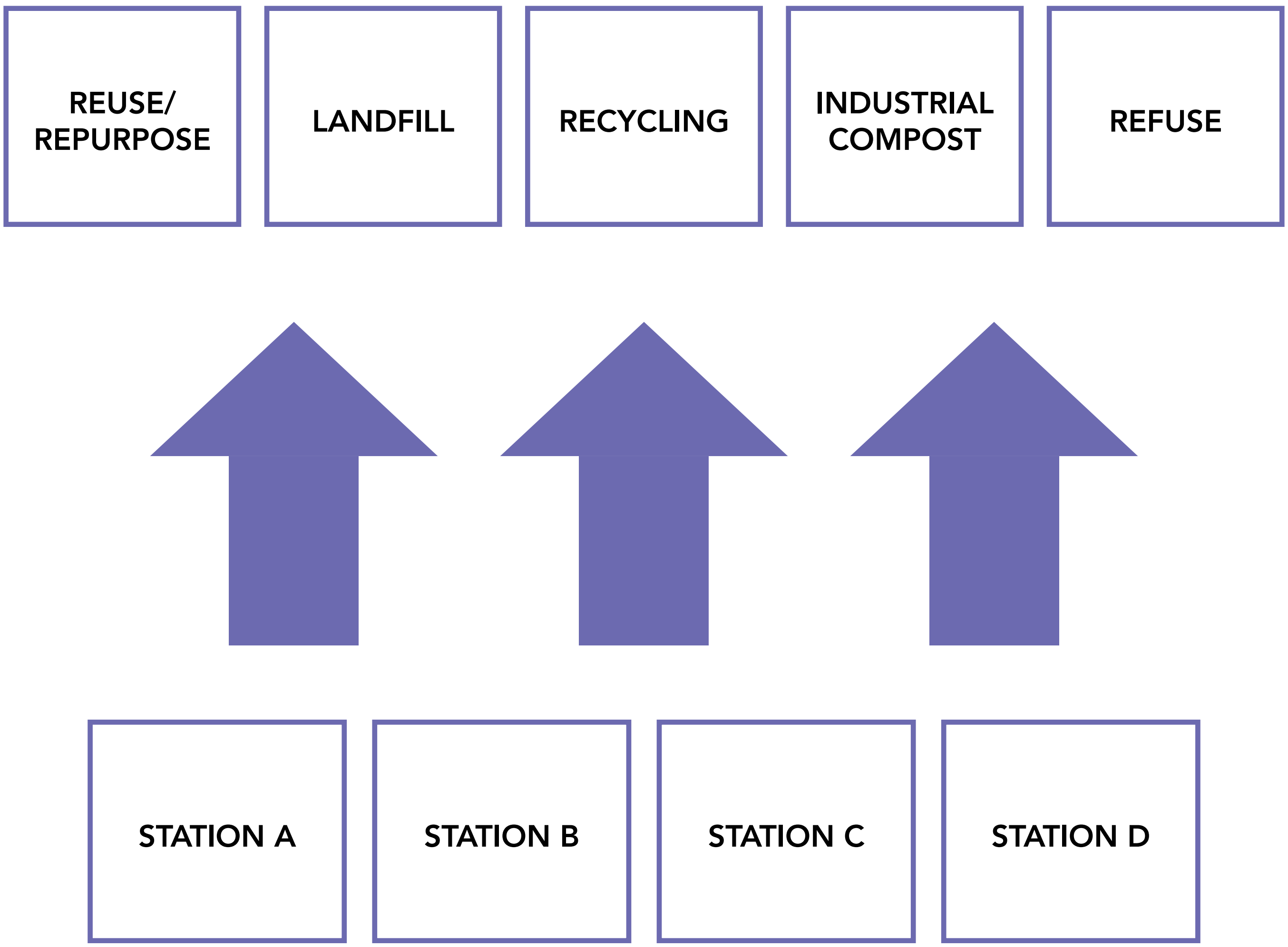
At each starting station place 12-14 Item Cards (Appendix C) in a labeled bag and one Recycling Center Reference Sheet (Appendix D).

Pairs will begin at Station A, B, C, or D. They will select a random Item Card from the bag. They will refer to the Recycling Center Reference Sheet to decide whether to put their item in a Landfill or Recycle it. After they decide, they will walk to the according station to dispose of their item.

This activity can be repeated until everyone in the group has gone through at least twice.

Appendix A

Activity Set Up - Activity A, Round 2



At each starting station place: 12-14 Item Cards (Appendix C) in a labeled bag, one Recycling Center Reference Sheet (Appendix D), and 1 Disposal Options Sheet Appendix E.

At the Reuse/Repurpose Table, place pencils and copies of Repurpose idea sheet (Appendix F.) Pairs will begin at the same stations as Round 1. They will select a random Item Card from the bag. They will refer to the Recycling Center Reference Sheet, and Disposal Options sheet to determine where their item could go. After they decide, they will walk to the according station to dispose of their item. This activity can be repeated until everyone in the group has gone through at least twice. Students at the Reuse/Repurpose table may take longer as they will fill out an idea sheet.

Appendix B

Station Names

Print and cut the station names. Secure station names with tape to the flat surfaces.

Station A

Appendix B

(Continued)

Station B

Station C

Appendix B
(Continued)

Station D

Reuse/ Repurpose

Appendix B
(Continued)

Landfill
Recycling

Appendix B
(Continued)

Industrial Compost
Refuse

Appendix C

Item Cards

Print one sided and cut Item Cards. Place 12-14 random Item Cards in each paper bag at each starting station. Write "Item Cards" on the bag. Note: Duplicate cards as needed.

#1 PET (water bottle)

#6 PS (egg carton)

#6 PS (packing peanuts)

#6 PS (Styrofoam cups)

Appendix C
(Continued)


#6 PS (Styrofoam to-go containers)


#3 PVC (PVC pipes)


#6 PS (Styrofoam wig head)


#6 PS (swimming kick boards)

Appendix C
(Continued)

#2 HDPE (milk jug)

#1 PET (peanut butter jar)

#4 LDPE (plastic bag)

#1 PET (Jell-o container)

Appendix C
(Continued)

#4 LDPE (Ziploc bag)

#7 All other plastics (sunglasses)

#6 PS (cutlery)

#5 PP (straws)

Appendix C
(Continued)

 #3 PVC (shampoo bottle)	 #3 PVC (large industrial pipes)
 #6 PS (Styrofoam lunch tray)	 #2 HDPE (hula hoops)

Appendix C

(Continued)

#3 PVC (vinyl records)

#4 LDPE (frozen bag of corn)

#3 PVC (translucent pencil pouch)

#4 LDPE (cellophane roll)

Appendix C
(Continued)

#2 HDPE (yogurt container)

#7 All other plastics (toothbrush)

#5 PP (squeezable ketchup, mustard, and relish containers)

#2 HDPE (orange juice jug)

Appendix C
(Continued)

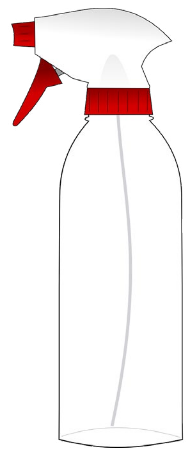
#7 All other plastics (5 gallon water jug)

#1 PET (mouthwash container)

#2 HDPE (motor oil bottle)

#1 PET (water bottle caps)

Appendix C
(Continued)

 #2 HDPE (laundry detergent container)	 #2 HDPE (Windex spray bottle)
 #7 All other plastics (swimming goggles)	 #7 All other plastics (cell phone cases)

Appendix C
(Continued)

#7 All other plastics (CDs)

#7 All other plastics (PLA) (to-go cup)

#7 All other plastics (to-go forks)

#7 All other plastics (PLA)
(to-go plastic bag)

Appendix C
(Continued)

#7 All other plastics (PLA)
(to-go cup with lid)

#7 All other plastics (PLA) (to-go bowl)

#7 All other plastics (PLA) (to-go lid)

#5 PP (squeezable syrup container)

Appendix C
(Continued)

#3 PVC (rubber duckies)

#4 LDPE (frozen bag of peas)

#1 PET (perler beads)

#4 LDPE (Tupperwear lids)

Appendix C
(Continued)

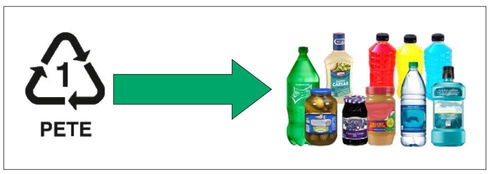
 #5 PP (clear party cup)	 #5 PP (butter container)

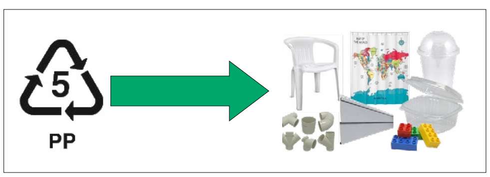
Appendix D

Recycling Center Reference Sheet

Print two copies of this page, cut in half, and place one at Stations A-D. Note: Duplicate pages as needed.

Recycling Center Accepts:





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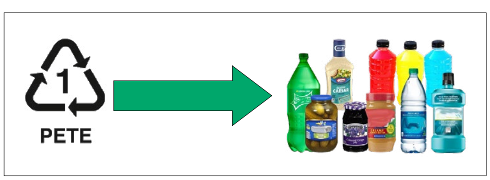
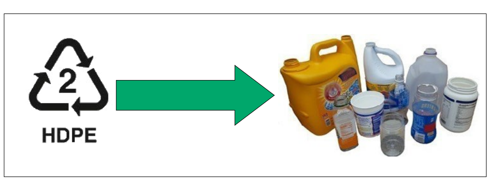
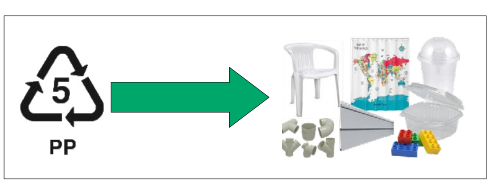
Recycling Center Accepts:







Recycling Center does NOT Accept:

Appendix E

Disposal Options Sheet

Print 4 copies. Place one sheet at each station A-D.

Reuse

To use an object again for the same purpose it was intended

Repurpose

To use an object for a new purpose other than it was originally intended

Industrial Compost

Organic waste products go through a multi-step process converting items into usable soil.

Refuse

Say no to purchasing or using specific products with plastics, often single use plastics

Appendix F

Repurpose Idea Sheet

Print, cut apart, and place repurpose idea sheet and pencils at the reuse/repurpose station for Round 2. Print as many as needed for your group.

Item: **Plastic Number:**

Repurpose Idea:
Think of a new way you can use this plastic! Describe the plastic's new use in the space provided.

Item: **Plastic Number:**

Repurpose Idea:
Think of a new way you can use this plastic! Describe the plastic's new use in the space provided.

Item: **Plastic Number:**

Repurpose Idea:
Think of a new way you can use this plastic! Describe the plastic's new use in the space provided.

The SciGirls Strategies

Proven Strategies for Engaging Girls in STEM

The **SciGirls** approach is rooted in research about how to engage girls in STEM. A quarter of a century of studies have converged on a set of common strategies that work, and they have become the framework for **SciGirls**. The original set of strategies, created in 2010, were updated in 2019 to reflect current research.

1 Connect STEM experiences to girls' lives.

(Boucheretal.,2017;Sammetetal.,2016;Bonner&Dornerich,2016;Ereteetal.,2016;Stewart-Gardineretal.,2013;Civil,2016;Verdinetal.,2016;Cervantes-Soon,2016).

Make STEM real and meaningful by engaging girls in activities that draw on their interests, knowledge, skills, culture, and lived experiences. This helps girls develop a STEM identity and increases their sense of belonging in STEM.

2 Support girls as they investigate questions and solve problems using STEM practices.

(Buckholz et al., 2014; Kim, 2016; Scott & White, 2013; Farland-Smith, 2016; Munley & Rossiter, 2013; Civil, 2016; Riedinger et al., 2016)

Engage girls in hands-on, inquiry-based STEM experiences that incorporate practices used by STEM professionals. Let girls take ownership of their own STEM learning and engage in meaningful STEM work to positively impact their identities and re-define how they see STEM.

3 Empower girls to embrace struggle, overcome challenges, and increase self-confidence in STEM.

(Blackwell et al., 2007; Dweck, 2000; Halpern et al., 2007; Kim et al., 2007; Mueller & Dweck, 1998)

Help girls focus on and value the process of learning by supporting their strategies for problem solving and letting them know their skills can improve through practice. Support girls to develop a growth mindset—the belief that intelligence can develop with effort and learning.

4 Encourage girls to identify and challenge STEM stereotypes.

(Allenetal.,2017;Carlietal.,2016;Cheryanetal,2015;Robnett,2016;Allenetal.,2017;Carloneetal.,2015;Sammetetal.,2016,Scottetal.,2014;Tanetal.,2013;Dasguptaetal.,2014;Verdin et al., 2016; Civil, 2016; Boucher et al., 2017)

Support girls in pushing against existing stereotypes and the need to conform to gender roles. Helping girls make connections between their unique cultural and social backgrounds and STEM disciplines will negate potential stereotype barriers.

5 Emphasize that STEM is collaborative, social, and community-oriented.

(Capobiancoetal.,2015;Diekmanetal.,2015;Leaper,2015;Riedingeretal.,2016;Robnett,2013;Parker&Rennie,2002;Scantlebury&Baker,2007;Werner&Denner,2009;Cakiretal.,2017; Sammet et al., 2016; Boucher et al., 2017; Clark et al., 2016; Leaper, 2015)

Highlight the social nature of STEM to increase interest and motivation and change the stereotypical perception that STEM jobs require people to work alone. Girls benefit from a supportive environment that offers opportunities to build relationships and form a collective identity.

6 Provide opportunities for girls to interact with and learn from diverse STEM role models.

(Kochetal.,2015;Leaper,2015;Adamsetal.,2014;Jethwanietal.,2017;Kessels,2014;O'Brienetal.,2016;Levineetal.,2015;Hughesetal.,2013;Cheryanetal.,2015;Weisgram&Diekman,2017)

Introduce girls to diverse women role models from varied STEM career pathways to help girls see potential futures and develop resilient STEM identities. Positive role models can increase girls' interests in, positive attitudes toward, and identification with STEM.

Send us your Feedback!

Have you tried one (or more!) of the activities? Let us know how it went! We work with the Center for Applied Research and Education Improvement at the University of Minnesota to evaluate this project. Click on the button below to fill out their short evaluation form and help us collect valuable feedback for improvement!

4hpolymers.org/evaluation

NATIONAL PEER REVIEWED

MODULE 5

GRADES 3-5

Sustainable Polymers

Plastics of the Future for a Green, Clean World

A 4-H STEM Curriculum for Grades 3-5 | 4hpolymers.org

National Science Foundation | NSF Center for Sustainable Polymers

4-H Polymer Science Curriculum for

Grades 3-5

4hpolymers.org

The themes of these modules touch on the prevalence and impact of plastics in everyday life. Plastics are versatile materials that come in different shapes, sizes, and exhibit different material properties. Scientists and engineers are working on new ways to create, use, and recycle plastics, so we can use plastics for their many advantages and lessen their effects on our environment.

Each module will include "Tips for Facilitators" and the Science and Engineering Practices, as well as opportunities to use "I Wonder" Boards. In addition, these modules incorporate the SciGirls Strategies for gender equitable STEM learning. We encourage instructors to collect feedback throughout this module and submit via this evaluation form: 4hpolymers.org/evaluation.

National Science Foundation
NSF Center for Sustainable Polymers

Tips and Callouts

Facilitator Tips

These tips provide strategies and helpful suggestions for facilitators.

"I Wonder" Boards

These boards should be used to track children's questions and ideas during the lesson for further investigation. This tool promotes experiential learning by youth while encouraging curiosity and discovery. Basic "I Wonder" Boards have "I Wonder..." written at the top of a large sheet or white board.

Science and Engineering Practices

The Next Generation Science Standards (NGSS) identifies eight practices of science and engineering that are essential for all students to learn. Using these practices, youth make sense of phenomena and use these skills to investigate the world and design and build systems.

SciGirls Strategies

Based on educational research, the SciGirls Strategies are used to target and engage girls in STEM learning, but have also been proven to work with all learners, including underrepresented youth. See the SciGirls Strategies handout at the back of the module for a more detailed explanation.

Module 5

Buy, Sell, Create
Primary Author: Jennifer McCambridge

Introduction

MODULE SUMMARY

Youth work in small groups to make decisions on how to create a type of plastic (traditional (oil-based or bioplastic) through a simulation game. Youth will use money tokens to buy the supplies needed to create a plastic item. Youth will have the opportunity to dispose of their items in multiple ways. As resources are depleted or replenished, youth will discover strategies on how to sustain the creation of their plastics when the supply of materials is variable. If your group has access to a microwave, youth can create their own bioplastic. If no microwave is available, youth can take the instructions home to complete.

Total lesson time needed for Module 5: 45-60 minutes not including set up time
Getting Ready: 10-20 minutes total

- Activity A: Buy, Sell, Create (25-30 minutes)
- Activity B: Make Your Own Bioplastic! (10-15 minutes)
- Reflection/Wrap Up (10-15 minutes)
- Total estimated time for Module 5: 55-80 minutes, including set up time

  *Multiple rounds of the Buy, Sell, Create game can be played if desired.

Module Focus

LEARNING OBJECTIVES	• Youth will understand that some plastics are made from resources that are limited • Youth will learn that some plastics are made from resources that can be replenished or grown • Youth will increase their awareness of scientific and engineering solutions that reduce the impact of humans on the Earth
SCIENCE & ENGINEERING PRACTICES *Youth will engage in the following NGSS Practices:*	• Developing and using models • Engaging in argument from evidence
CONCEPTS & VOCABULARY	• **Bioplastic**: polymers that come from biomass and are often made from starch-containing plants, such as corn and potatoes. Many of these bioplastics are compostable • **Non-renewable resource**: a resource that is only available in limited quantities and takes a long time to be replenished (for example millions of years) • **Plastic**: a type of human-made material. Usually made from petroleum or oil (traditional) but plastics can be made from renewable resources like plants (bioplastic); All plastics consist of polymers. • **Renewable resource**: a resource that can be replenished, often within one person's lifetime • **Sustainable**: able to be maintained or run continuously

Facilitator Preparation

MATERIALS - ACTIVITY A

- ☐ Copies of money cards for each group (at least 2 pages/24 coins per group) (may use chips/ tokens in place of money cards)
- ☐ Copies of supply cards (at least 2-3 pages of corn/oil and 2 pages of chemical/factory per group)
- ☐ Copies of plastic item cards (at least 2-3 per group) (or may use real plastic items)

GETTING READY - ACTIVITY A (5-10 MINUTES)

- Make copies of money, supply, and plastic item cards in Appendix A. Print single-sided and cut apart.
- Consider how you will divide youth into their groups. This game works best with groups of 2-3 5
- Set up a "marketplace" that displays the "recipe" for each plastic type
- Print the "recipe" for creating plastics on chart paper or a whiteboard (or copy the Recipes handout-Appendix B)-1 per group
- Recipes:
    - Traditional plastics require two oil cards, two chemical cards, and one factory card to create
    - Bio-based plastics require three plant cards, two chemical cards, and one factory card to create
    - Each card (oil, plant, chemical, or factory) requires one money card to purchase
    - You may want to designate a helper to assist as you guide this activity. The helper could be another adult or an older youth
    - Set up a "Scrapyard/Disposal" where youth can sell or recycle their plastics

Facilitator Tip
Practice this game yourself before implementing with youth, so that you have experience with how it works.

5 SciGirls
STEM is collaborative, social, and community-oriented

Facilitator Preparation (Continued)

MATERIALS - ACTIVITY B

- ☐ Microwave oven
- ☐ For each youth:
    - Zipper-top plastic bag (sandwich or quart size bag)
    - 1 Tablespoon cornstarch
    - 1 Tablespoon water
    - 2 drops of corn/ vegetable oil
    - Food coloring (optional)

GETTING READY - ACTIVITY B (5-10 MINUTES)

- Locate or provide microwave access for group.
- Collect materials for each youth. You may have youth measure out quantities themselves or provide each youth with pre-measured amounts.
- Watch a video illustrating the basic procedure: https://youtu.be/xLzaI95x5MQ

Background Information for the Facilitator

It is no mystery that plastics are everywhere - from grocery bags and water bottles to high-tech medical devices and computers. **Plastics** are widely used because they are durable, lightweight, and easy to produce. The majority of plastics that consumers use every day are created from petroleum (also known as oil). Petroleum is a **non-renewable resource**, meaning it does not replenish itself readily. For example, the world's current oil deposits were formed millions of years ago. As the world's demand for plastics and other non-renewable resources continues to grow, the depletion of these resources is an increasingly important issue. Many scientists and engineers are working to replace traditional, oil-based plastics with plastics made from **renewable resources**, such as plant matter. Plastics created from renewable resources are often called **bioplastics**. The most common bioplastic in today's market is polylactic acid (referred to as PLA), which is made from corn. PLA is a type of bioplastic that can be composted at industrial compost facilities, meaning it will break down into soil in the proper environment. Even with these new advancements in plastic materials, scientists and engineers are still working on how to create bioplastics that can serve the same purpose as current traditional plastics, yet remain cost-effective. There is still a lot of work that needs to be done to create a truly **sustainable** form of plastic that can meet our everyday needs. 5

The time scale used when considering if a resource is renewable can be a challenging concept for young people. For example, trees may take many years (which may seem like forever from the youth perspective) to replenish, but if managed properly, trees are considered a renewable resource. It may be helpful to frame these time scales as whether or not they can occur within a person's lifetime.

Renewable materials aren't automatically better for the environment. Factors in the creation, processing, transportation, use, and disposal of an item must be examined to determine the cost/benefits of using such a material.

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“I Wonder Board”

While the professional science and engineering communities often require specialized training and tools, anyone can learn to engage in similar processes and practices! Activities encourage “wondering” and emphasize how important it is for adults to model and encourage curiosity in youth. These “wonders” are often turned into questions that can be investigated or studied. Consider posting a “I Wonder” board (see Front Matter for full explanation) to help surface these “wonders” and perhaps provide inspiration for your group to dig deeper into their curiosities.

Activity A

Buy, Sell, Create (25-30 minutes)

Youth will trade money cards to obtain the resources required to make a plastic. As resources either deplete or are replenished, youth will discover how the availability of resources can influence the types of products that can be created.

OPENING QUESTIONS AND PROMPTS

Facilitate a group discussion to get youth thinking about what they know about the main learning objectives of the module. 1 You may ask the following prompts. There is overlap in some questions between modules so you may want to develop new broad, open-ended questions for your group, if needed.

- Describe plastic items you use each day. Explain the purpose of each item.
- Explain how you dispose of these items once they have served their purpose.

PROCEDURE (EXPERIENCING)

1. Divide youth into groups of 2-3. 5 Each group will be trying to purchase the supplies needed to create a plastic item.

Facilitator Tip
Invite youth to this simulation game in which their goal is to create plastic. Explain that a simulation is similar to a model; it creates a model of a real-life setting in which they will need to make choices. The "recipes" they use will simulate or mimic the materials and resources needed to make plastic.

1 SciGirls

Connect STEM experiences to lives

5 SciGirls

STEM is collaborative, social, and community-oriented

Science and Engineering Practices
Note that youth are engaging in one of the Science and Engineering Practices: 'Developing and using models.'

2. The goal of the game is to collect as many **plastic item cards** as possible without running out of money. Designate half of the pairs/small groups to follow the recipe for traditional plastics; the other half will follow the recipe for bioplastics. If there are uneven numbers, assign more groups to the traditional plastics as this type of plastic is more prevalent in consumer goods.

3. Recipes:
   - Traditional plastics require two oil, two chemical, and one factory card to build.
   - Bioplastics require three plant, two chemical, and one factory card to build.
   - Each card (oil, plant, chemical, or factory) requires one money card to purchase.

4. One facilitator should act as the "marketplace". Youth can purchase oil, plants, chemicals, or factories from the marketplace. If there is an additional facilitator or helper present, the second person should act as the "disposal". One facilitator can serve as both the marketplace and the disposal if necessary.

5. Youth will begin with 24 money cards per group. Youth will take turns buying up to three items in each round. It will take at least two rounds before youth will be able to combine their supplies to make a plastic item.

6. During each round, groups can do each of the following things once:
   - Purchase supplies.
   - Trade in their supplies to receive up to three plastic items. (If accessible, use real items. If you are unable to collect real items, use the cards with pictures of the items.)
   - Dispose of plastic items and receive money or resources in return.
     - At the "scrapyard/disposal" station, youth can trade **one** traditional plastic item to:
       - sell = receive **six** money cards
       - recycle = receive **one** oil card and **three** money cards

- Youth can trade **one** bioplastic item to:
    - sell = receive **six** money cards
    - recycle/compost = receive **two** plant cards and **three** money cards

7. Continue taking turns creating plastic items, disposing of items, and buying new supplies. Eventually the oil cards will deplete and youth will have to make decisions on how to continue playing the game. Oil cards are the only cards that should deplete; facilitators can replenish plant, chemical, and factory cards as necessary. You can run the game for a certain number of rounds or until the youth run out of money.
8. If time allows, repeat the game with youth following the recipe for the other type of plastic (e.g. groups that created traditional plastics should now create bioplastics, and vice versa).

SHARE/PROCESS/GENERALIZE

Help guide youth as they question, share, and compare their observations. 2 You may choose one of the questions below as a prompt. If necessary, use more targeted questions as prompts to get to particular points. Remember these questions are not about getting one right answer.

- Explain what happens when you couldn't buy more oil cards.
- Describe the challenges you had when trying to build bio-based plastics.
- Compare and contrast these with the challenges of making a traditional plastic.
- Describe the challenges we face by using only plastic made from non-renewable resources.
- Describe the challenges we face by using only plastic made from renewable resources.

Science and Engineering Practices
Note that youth are engaging in the Science and Engineering Practice of 'Constructing explanations. Add this to your list created earlier. 3

2 SciGirls

Support as they investigate using STEM practices

3 SciGirls

Embrace struggle, overcome challenges, and increase self-confidence in STEM

Activity B

Make Your Own Bioplastic! (10-15 minutes)

If the group has access to a microwave, youth will create their own bioplastic from cornstarch. If no microwave is available, youth can take home the instructions. This activity can be used to reinforce the ideas from the Buy, Sell, Create simulation game: the microwave is the factory, the cornstarch and corn oil represent renewable resources, water is a necessary supply. (Helpful Video: https://www.youtube.com/watch?v=xLzaI95x5MQ)

OPENING QUESTIONS AND PROMPTS

Facilitate a group discussion to get youth thinking about what they know about the main learning objectives of the module. 1 You may ask the following prompts. There is overlap in some questions between modules so you may want to develop new broad, open-ended questions for your group, if needed.

- Explain what you know about bioplastics.
- Describe what you think are the advantages and disadvantages of making bioplastic.

PROCEDURE (EXPERIENCING)

1. Each youth should combine the cornstarch and water in a zipper-top plastic bag. Mix the two by squeezing the bag. You may use small glass bowls as an alternative to using plastic bags, and stir with a spoon.
2. After mixing, youth should add two drops of corn/vegetable oil. If desired, youth may also add a couple drops of food coloring. Again, mix the contents by squeezing them together in the bag.
3. Youth should close but not fully seal the bag. Leave a small vent in the zipper top opening. Microwave the bag and contents on high for 20-25 seconds. The bag and contents will be hot, use a pad to remove the bag or an adult should remove the bag from the microwave.
4. Let the plastic cool for 2-3 minutes in the bag. After cooling, youth can touch, shape, and play with their plastic! Safety note: Even though the plastic is made from edible materials, youth should not eat or taste their bioplastic.

SHARE/PROCESS/GENERALIZE

Help guide youth as they question, share, and compare their observations. 2 You may choose one of the questions below as a prompt. If necessary, use more targeted questions as prompts to get to particular points. Remember these questions are not about getting one right answer.

- Describe what you think your bioplastic would be good for.
- Explain how you think the bioplastic you made might be more or less sustainable than other types of plastic.
- Tell us what you think about how the process of making bioplastic might or might not be environmentally friendly. 5

Ensure Concept Understanding

At this point, it is important to ensure that the terms **bioplastic, renewable resource, non-renewable resource, plastic, and sustainable** have been introduced or discovered by the youth. The goal is to have the youth discover terms and concepts on their own. After youth have stated and shared their understanding of the concepts, then you may introduce the terminology used by scientists to refer to the concepts. Facilitate a brief conversation on the importance of the concepts.

The facilitator will also want to ensure that youth understand how important recycling is for traditional plastics to continue being used in the game. How might youth/families change their own recycling habits and what benefits might that have on our natural resources? 1 5

1 SciGirls

Connect STEM experiences to lives

2 SciGirls

Support as they investigate using STEM practices

5 SciGirls

STEM is collaborative, social, and community-oriented

SCIENCE & ENGINEERING IN EVERYDAY LIFE - CONCEPT APPLICATION

Facilitator Tip
When engaging youth in inquiry-based learning, hands-on activities serve as vehicles for learning new concept knowledge and skills; however, it is the application of new knowledge or skills to independent, real-world situations that is the critical factor in the learning process. Thus, to complete the cycle of experiential learning, it is important to intentionally provide youth specific opportunities for authentic applications

REFLECTION

Reflecting on experience is an essential part of learning and "making meaning of" an experience. Now is an opportunity to bring the youth together and discuss the things they experienced throughout the module. You may want to use a "circle share" process to facilitate this discussion. Have youth sit in a circle with you. Some general questions you can ask the youth include:

- Did you try something that you've never done before?
- What is something new you learned from the activities today?
- How were you a scientist or engineer today?
- Which of the eight practices of science and engineering did you use today?

1 SciGirls

Connect STEM experiences to lives

5 SciGirls

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EXTEND THE LEARNING

- **Science at Home** - These are possible extension activities that can be used with youth as time/interest allows. If you meet multiple times, you might invite youth to do a take home activity and have them report back or bring in an item as described. This helps support application of the concepts you've explored in this module. These activities are also shared on the **Science at Home** handout.

Facilitator Tip
Science at Home can be copied and sent home with the youth, or emailed. It includes a brief summary of the module and provides several activity ideas. It encourages families to engage in science learning together, supporting application of the concepts.

- **Service Learning in Action** - Planning and carrying out a service-learning project can be an exciting opportunity for youth to apply their learning as they work to address local and world needs. In Module 6: Service Learning, youth will dive deep into the experiential process by creating and carrying out a service project related to plastics. Below are some suggested activities and real-world service-learning examples that you can explore with your students related to plastics in our world.

- **Real-World Example** - Scientists Anne Schauer-Gimenez, Allison Pieja, and Molly Morse became inspired as young people to solve the plastic problem and are now working to create biopolymers that they hope one day will replace traditional plastics. To learn more, visit: https://www.npr.org/2019/06/17/728599455/replacing-plastic-can-bacteria-help-us-break-the-habit

SERVICE IDEAS

- Upcycle Plastics into Art - Combine your desire to make positive change with your artistic spirit by upcycling plastics into art! Check out Washed Ashore - https://washedashore.org/iamdc/ to learn how to organize a team to collect plastic trash, design a piece of art, and then work together to create the art piece. When displaying the art, share how you transformed single-use plastic into something lasting and beautiful.

- Share Groundbreaking Science - Work with others to research innovative scientists that are working to solve the plastics problem. Create a slideshow to share with your class or school. Share ways you use the same science and engineering practices to learn about polymers. Check out the University of Minnesota NSF Center for Sustainable Polymers https://csp.umn.edu for examples of real researchers working to create sustainable plastics.

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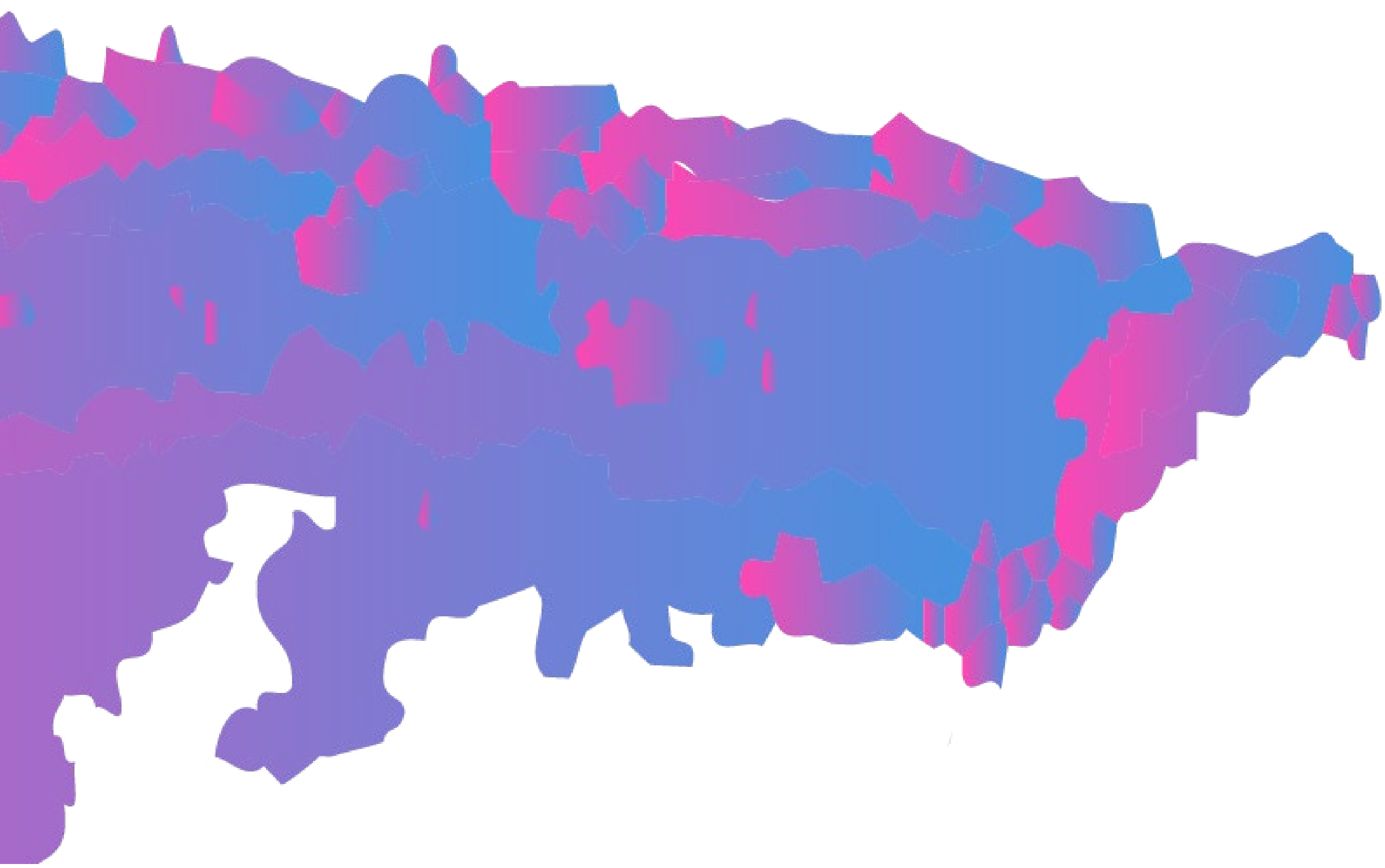


Science at Home

Hello Families,

Your child is exploring science and engineering in **Sustainable Polymers: Plastics of the Future for a Green, Clean World.** We hope you will try these "Science at Home" activities at home.

This week our activity, **Buy, Sell, Create**, focused on students making decisions around purchasing renewable and non-renewable resources to build a desired type of plastic (traditional or bio-based). Your child utilized money cards to buy needed supplies to create a plastic item and discovered ways to dispose of the items after product use. Students also developed strategies on sustaining building when resources are depleted or replenished.

Try these "Science at Home" Activities:

- **Next Level Bioplastic Making** - Take your bioplastic making to the next level by making a bioplastic bowl.
    - **Watch the first video**: https://youtu.be/Cqg-QpaF1lk for instructions on making cornstarch polymer and the second video for instructions on making the bowl: https://youtu.be/8nxuO3SjMQM?t=20
- **Go on a bioplastic hunt**: See how many bioplastics you can find in your community, look for items made from bioplastics at restaurants or stores. Make a list or take a picture of the items you find. Create a bioplastic guide, including how to identify a bioplastic, where to purchase bioplastics, and ways to make more sustainable choices.
- **Watch a Video and Discuss How Industrial Composting Works**: Watch the following video and discuss how industrial composting works:
    - https://www.youtube.com/watch?v=s_27lJ3NQO4&feature=youtu.be
- **Learn From Other Countries**: Explore how other countries handle waste, recycling, or re-use materials. There are many non-fiction children's books that help tell this story, such as:
    - **One Plastic Bag** - http://oneplasticbag.com/
    - **Read the Book** - Soda Bottle School - https://www.cbcbooks.org/cbc_book/the-soda-bottle-school-2/
    - **Building with Soda Bottles** - http://hugitforward.org/who-we-are/
    - **Share Your Knowledge**: Share what you've learned about bioplastics and plastic reduction with others in your club, school, or community. Make a creative poster, short video, or speech that you could use to teach others about single-use plastics.

Appendix A


Money

Money

Money


Money

Money

Money


Money

Money

Money


Money

Money

Money

Appendix A *(Continued)*

Plant

Plant

Plant

Plant

Plant

Oil

Plant

Plant

Oil

Plant

Plant

Oil

Appendix A *(Continued)*


Chemicals


Chemicals


Factory


Chemicals


Chemicals


Factory


Chemicals


Chemicals


Factory


Chemicals


Chemicals


Factory

Appendix A *(Continued)*

Traditional Plastic

Bioplastic

Traditional Plastic

Bioplastic

Traditional Plastic

Bioplastic

Traditional Plastic

Bioplastic

Traditional Plastic

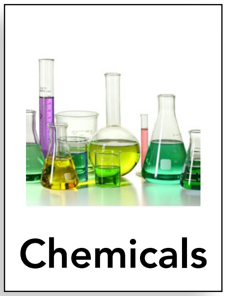
Bioplastic

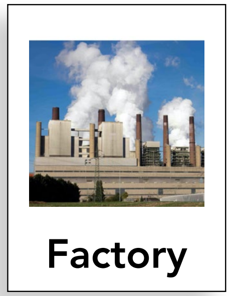
Appendix B

Recipe Card and Disposal Option Cards

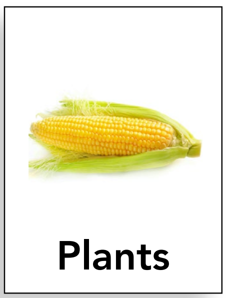
Traditional Plastics

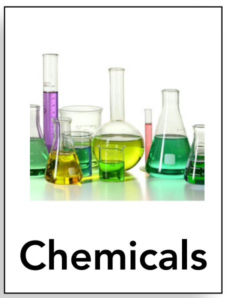
2 

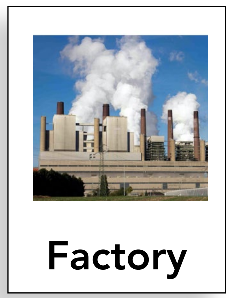
+2 

+1 

Bio-based Plastics

3 

+2 

+1 

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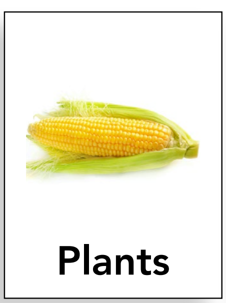
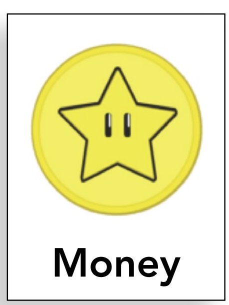


"Costs" 1 money card



Appendix B

Recipe Card and Disposal Option Cards

DISPOSAL OPTIONS TO EARN MONEY CARD

Traditional plastic items:

- Sell = receive six money cards
- Recycle = receive one oil card and three money cards

Bioplastic items:

- Sell = receive six money cards
- Recycle/compost = receive two plant card and three money cards

DISPOSAL OPTIONS TO EARN MONEY CARD

Traditional plastic items:

- Sell = receive six money cards
- Recycle = receive one oil card and three money cards

Bioplastic items:

- Sell = receive six money cards
- Recycle/compost = receive two plant card and three money cards

The SciGirls Strategies

Proven Strategies for Engaging Girls in STEM

The **SciGirls** approach is rooted in research about how to engage girls in STEM. A quarter of a century of studies have converged on a set of common strategies that work, and they have become the framework for **SciGirls**. The original set of strategies, created in 2010, were updated in 2019 to reflect current research.

1

Connect STEM experiences to girls' lives.

(Boucheretal.,2017;Sammetetal.,2016;Bonner&Dornerich,2016;Ereteetal.,2016;Stewart-Gardineretal.,2013;Civil,2016;Verdinetal.,2016;Cervantes-Soon,2016).

Make STEM real and meaningful by engaging girls in activities that draw on their interests, knowledge, skills, culture, and lived experiences. This helps girls develop a STEM identity and increases their sense of belonging in STEM.

2

Support girls as they investigate questions and solve problems using STEM practices.

(Buckholz et al., 2014; Kim, 2016; Scott & White, 2013; Farland-Smith, 2016; Munley & Rossiter, 2013; Civil, 2016; Riedinger et al., 2016)

Engage girls in hands-on, inquiry-based STEM experiences that incorporate practices used by STEM professionals. Let girls take ownership of their own STEM learning and engage in meaningful STEM work to positively impact their identities and re-define how they see STEM.

3

Empower girls to embrace struggle, overcome challenges, and increase self-confidence in STEM.

(Blackwell et al., 2007; Dweck, 2000; Halpern et al., 2007; Kim et al., 2007; Mueller & Dweck, 1998)

Help girls focus on and value the process of learning by supporting their strategies for problem solving and letting them know their skills can improve through practice. Support girls to develop a growth mindset—the belief that intelligence can develop with effort and learning.

4

Encourage girls to identify and challenge STEM stereotypes.

(Allenetal.,2017;Carlietal.,2016;Cheryanetal,2015;Robnett,2016;Allenetal.,2017;Carloneetal.,2015;Sammetetal.,2016,Scottetal.,2014;Tanetal.,2013;Dasguptaetal.,2014;Verdin et al., 2016; Civil, 2016; Boucher et al., 2017)

Support girls in pushing against existing stereotypes and the need to conform to gender roles. Helping girls make connections between their unique cultural and social backgrounds and STEM disciplines will negate potential stereotype barriers.

5

Emphasize that STEM is collaborative, social, and community-oriented.

(Capobiancoetal.,2015;Diekmanetal.,2015;Leaper,2015;Riedingeretal.,2016;Robnett,2013;Parker&Rennie,2002;Scantlebury&Baker,2007;Werner&Denner,2009;Cakiretal.,2017; Sammet et al., 2016; Boucher et al., 2017; Clark et al., 2016; Leaper, 2015)

Highlight the social nature of STEM to increase interest and motivation and change the stereotypical perception that STEM jobs require people to work alone. Girls benefit from a supportive environment that offers opportunities to build relationships and form a collective identity.

6

Provide opportunities for girls to interact with and learn from diverse STEM role models.

(Kochetal.,2015;Leaper,2015;Adamsetal.,2014;Jethwanietal.,2017;Kessels,2014;O'Brienetal.,2016;Levineetal.,2015;Hughesetal.,2013;Cheryanetal.,2015;Weisgram&Diekman,2017)

Introduce girls to diverse women role models from varied STEM career pathways to help girls see potential futures and develop resilient STEM identities. Positive role models can increase girls' interests in, positive attitudes toward, and identification with STEM.

Send us your Feedback!

Have you tried one (or more!) of the activities? Let us know how it went! We work with the Center for Applied Research and Education Improvement at the University of Minnesota to evaluate this project. Click on the button below to fill out their short evaluation form and help us collect valuable feedback for improvement!

4hpolymers.org/evaluation

NATIONAL
PEER REVIEWED

MODULE
6
GRADES 3-5

Sustainable Polymers

Plastics of the Future for a Green, Clean World

A 4-H STEM Curriculum for Grades 3-5 | 4hpolymers.org

National Science Foundation | NSF Center for Sustainable Polymers

4-H Polymer Science Curriculum for

Grades 3-5

4hpolymers.org

The themes of these modules touch on the prevalence and impact of plastics in everyday life. Plastics are versatile materials that come in different shapes, sizes, and exhibit different material properties. Scientists and engineers are working on new ways to create, use, and recycle plastics, so we can use plastics for their many advantages and lessen their effects on our environment.

Each module will include "Tips for Facilitators" and the Science and Engineering Practices, as well as opportunities to use "I Wonder" Boards. In addition, these modules incorporate the SciGirls Strategies for gender equitable STEM learning. We encourage instructors to collect feedback throughout this module and submit via this evaluation form: 4hpolymers.org/evaluation.

National Science Foundation

NSF Center for Sustainable Polymers

Tips and Callouts

Facilitator Tips

These tips provide strategies and helpful suggestions for facilitators.

"I Wonder" Boards

These boards should be used to track children's questions and ideas during the lesson for further investigation. This tool promotes experiential learning by youth while encouraging curiosity and discovery. Basic "I Wonder" Boards have "I Wonder..." written at the top of a large sheet or white board.

Science and Engineering Practices

The Next Generation Science Standards (NGSS) identifies eight practices of science and engineering that are essential for all students to learn. Using these practices, youth make sense of phenomena and use these skills to investigate the world and design and build systems.

SciGirls Strategies

Based on educational research, the SciGirls Strategies are used to target and engage girls in STEM learning, but have also been proven to work with all learners, including underrepresented youth. See the SciGirls Strategies handout at the back of the module for a more detailed explanation.

Module 6

Service Learning

Primary Authors: Allison Keaney
and Steven Worker

Introduction

MODULE SUMMARY

Youth will participate in a service learning project allowing them to apply science knowledge and skills to a real-world situation. This module will guide youth through the stages of a service learning project. Youth will identify a need or problem and create a plan to address that need/problem; complete the service activity; and reflect upon the meaning, impact, and learning that stems from the activity.

Total lesson time needed for Module 6: varies depending upon service project
Getting Ready: time depends on project

- Activity A: Pre-Service Planning: 1-2 sessions for 60-105 minutes
- Activity B: Service in Action: 1-2 sessions with variable time depending on project
- Activity C: Reflecting, Sharing, Celebrating: 60-90 minutes

Module Focus

LEARNING OBJECTIVES	• Youth will apply their increased understanding and skills related to plastics to improve their home, school or community • Youth will identify, plan, implement, and evaluate a service learning project to make a positive contribution to their home, school, or community
SCIENCE & ENGINEERING PRACTICES *Youth will engage in the following NGSS Practices:*	• Asking questions (for science) and defining problems (for engineering) • Planning and carrying out investigations • Constructing explanations (for science) and designing solutions (for engineering)
CIVIC ENGAGEMENT PRACTICES	• Research and investigate problems or issues • Community mapping • Identify impact • Incorporate discussion of issues important to youth • Participate in governance

Facilitator Preparation

MATERIALS - ACTIVITY A

- ☐ Flip Chart Paper
- ☐ Markers
- ☐ Color sticker dots
- ☐ "Selecting a Project" page (Appendix B)
- ☐ "Project Planning Tool" (Appendix C)

GETTING READY

- Review Appendix A: Facilitator Tip Sheet
- Research service learning project examples and bring copies to share
- Plan on how to divide youth into small groups of 3-4 youth
- Determine guiding discussion questions
- Make copies of "**Selecting a Project**" page (Appendix B) - one per group
- Make copies of "**Project Planning**" tool (Appendix C) - one per group

MATERIALS - ACTIVITY B

- ☐ Completed "Project Planning tool (Appendix C; from previous activity)
- ☐ Tools, equipment, or supplies specified by the project plan
- ☐ Emergency contacts
- ☐ Contact list of community partners
- ☐ First aid kit
- ☐ Camera or smartphone with camera/video capabilities

GETTING READY

- Review project plan to determine:
    1. what are the planned action steps
    2. who is responsible for which action steps
    3. what are the materials needed to carry out the service plan
    4. who will gather the materials
- Make copies of the project plan for volunteers or project leads
- Communicate with volunteers, community organizations, or parents
- Determine who will take pictures/video

Facilitator Preparation (Continued)

MATERIALS - ACTIVITY C

- ☐ Project Evaluation Form (Appendix D)-1 per youth
- ☐ Any reflections gathered during the post-implementation reflection (Activity B)
- ☐ Crayons and markers
- ☐ Poster Board
- ☐ Tape
- ☐ Pictures or slide show
- ☐ Snacks/refreshments
- ☐ Supplies for celebration, as determined by your group

GETTING READY

- Gather materials
- Make copies of the Project Evaluation Form (Appendix D) - 1 per youth
- Print pictures or create a slideshow of youth carrying out the service learning project
- Invite family members, volunteers, and community partners to the service learning celebration
- Purchase snacks/refreshments
- Determine who will take pictures of the celebrations

Background Information for the Facilitator

Service-learning:

- combines service and learning objectives with the intent that the activity changes both the recipient and the provider of the service.
- involves active learning where youth draw upon previous lessons with the experience of performing service work.
- may involve direct service where youth come face-to-face with the receipts of their work, or
- may be indirect where services benefit the community or environment as a whole.
- offers opportunity for both youth learning and impact (making a difference for the youth involved and for the community).

Planning and carrying out a **service learning** project can be a motivating experience for young people. It offers a unique opportunity for youth to develop projects relevant to their community's needs, to deepen knowledge through intentional connection to learning, and to contribute as active citizens and change agents, making an impact on their community and the world around them. Benefits from service-learning may include increased civic engagement, improved academics, stronger ties to school, community, and society, and increased awareness of diversity and other cultures.

The planning and execution of a service learning project is an organic process. Best practices for facilitators include:

- Provide enough time for youth to discuss, collaborate, assess, make decisions, and reflect at each stage of the service learning project (pre-service planning, during the service, and post service).
- Throughout all three phases of the project, incorporate reflection time to help youth understand what they are learning, what needs to be done next, and what they've accomplished.

Facilitator Tip
Provide youth with service learning journals and plan time for youth to write or draw as ways to reflect on their experience.

- Balance time spent brainstorming ideas, discussion, planning and decision-making with a realistic timeline for completion of the project. Youth at this age want to take action and get things done. Help identify potential shorter-term projects and longer-range projects, depending upon your group and local situation.

For some youth, this may be their first service learning experience, and they may need more guidance during the pre-service planning and implementation. The actual project plan and timeline will be determined by the decisions of the group and the project they select. For youth in grades 3-5, a typical service learning project will span 3-4 meetings, but this will vary widely by the group, time available, and the project(s) selected.

Activity A

Pre-Service Planning (60-105 minutes)

This activity asks youth to apply what they have learned about polymers and the environmental concerns around plastics through a service learning project. Youth will be engaged in the investigating phase of the service learning project where they will discuss community needs, decide on a community need to address, and create a project to meet that need. During the planning and preparation phase, youth will create a project plan, outline the activities for the project, and identify the people responsible for those activities. Youth will discuss and select date, location, and other logistics for the completion of the service project.

Experience 1: Investigating - Large Group Discussion (15 – 30 minutes)

OPENING QUESTIONS AND PROMPTS

- Think about what we have learned about plastic use and the environment. Explain some problems/issues with plastics that you might want to address. 1
- Describe additional things you might need to learn to address these problems/issues. What questions do you have or what do you wonder about?
- Identify people in your school or community who might be helpful as resource individuals for your project (e.g., teachers, school custodian, community leaders, family members).

1 SciGirls
Connect STEM experiences to lives

PROCEDURE (EXPERIENCING)

1. Lead a large group discussion with the youth that focuses on "needs" using the questions below. Use flip chart paper to write the responses:
   - Please share what the term "need" means to you. 1
   - Describe what you understand to be a personal need, a family need, a community need, and a need in our larger society or world. Explain how they differ; discuss how they are similar. 1 5
2. Lead a discussion with the whole group that focuses on home, school/program site, or community concerns or needs.

Facilitator Tip
Facilitators might wish to identify a focus area prior to this discussion. Will your group focus on a need in your community/your school or program site/within the homes of the youth? The facilitator can then guide the necessary discussion.

3. Possible approaches for discussion are:
   - **School and Community Mapping**: Describe where and when plastics are used in your school. Discuss where and when plastics are used in your broader community (streets, parks). Describe the disposal of plastic products.
   - **Review Current News Sources**: Switch the group or facilitate the searching of online news sources. Ask the youth to identify challenges they may find in the news with regard to plastics or other environmental issues.

1 SciGirls

Connect STEM experiences to lives

5 SciGirls

STEM is collaborative, social, and community-oriented

4. **Brainstorm Potential Solutions**: Lead a brainstorm session using these possible prompts:

    - How might we make a difference in your homes, school or community? What is the problem we are trying to address?
    - Discuss strategies to reduce, refuse, reuse, or recycle plastics at your school or in our community.
    - Post ideas on flip chart paper. Group similar service ideas together using different color markers or colored dots. Discuss ideas. 1 5

5. Identify the top three issues or needs to address. Write these on a separate piece of flip chart paper.

SHARE/PROCESS/GENERALIZE

Help guide youth as they question, share, and compare their observations. 2 You may choose one of the questions below as a prompt. If necessary, use more targeted questions as prompts to get to particular points. Remember these questions are not about getting one right answer.

Guide the group to consensus on **one** issue they will choose to address.

Facilitator Tip
Facilitators might wish to identify a focus area prior to this discussion. Will your group focus on a need in your community/your school or program site/within the homes of the youth? The facilitator can then guide the necessary discussion.

- From our top three issues, explain one problem we are able to help solve.
- Explain how your new understanding of plastics can be used to help solve the issue you selected.
- Given the resources we have (people, time, transportation, money) explain ways we can contribute to our community/school? What resources do we need? 5

1 SciGirls

Connect STEM experiences to lives

2 SciGirls

Support as they investigate using STEM practices

5 SciGirls

STEM is collaborative, social, and community-oriented

Experience 2: Selecting a Project (15-30 minutes)

PROCEDURE (EXPERIENCING)

1. Break the youth into pairs or small groups of 3-4. 5
2. In their small group, have youth brainstorm project ideas based on the issue identified in the larger group. Have youth discuss options and record ideas on the "Selecting a Project" page (Appendix B).
3. Instruct youth to decide one project idea and detail why they chose that specific idea. Ask youth to be prepared to share ideas with the larger group.
4. Gather the small groups back together. Ask each small group to report to the larger group their choice and reason for selecting that specific project.
5. Based on your situation, ask the youth to vote on the final project(s) to be planned, or determine another method of selecting the final project(s).

Facilitator Tip
To help ensure all youth are able to contribute to a project, you may want to allow options for several different projects (perhaps around the central theme) or different iterations (same project, different timing or location). Determine ideal group size based on your group, setting, and projects.

SHARE/PROCESS/GENERALIZE

Help guide youth as they question, share, and compare their observations. 2 You may choose one of the questions below as a prompt. If necessary, use more targeted questions as prompts to get to particular points. Remember these questions are not about getting one right answer.

- Explain why you chose this project.
- Describe the main goal you want to accomplish when doing this project.

2 SciGirls

Support as they investigate using STEM practices

5 SciGirls

STEM is collaborative, social, and community-oriented

Experience 3: Planning the Project (30-45 minutes)

PROCEDURE (EXPERIENCING)

1. In their small groups, youth will discuss the components of the project (who, what, when, where, why) and capture their recommendations using the Project Planning Tool (Appendix C).
2. Ask youth to prepare a short presentation of their project plan with the larger group.
3. Ask each small group to present their project plan to the larger group.
4. As needed for your setting, ask youth to write up their plan on a computer or tablet.

Facilitator Tip
Communicate project plans to children's parents so they are aware and can support their child's participation.

Science and Engineering Practices
Note that youth are using the Practices of Science and Engineering: 'Asking questions and defining problems,' and 'Planning and conducting investigations.'

SHARE/PROCESS/GENERALIZE

Help guide youth as they question, share, and compare their observations. 2 You may choose one of the questions below as a prompt. If necessary, use more targeted questions as prompts to get to particular points. Remember these questions are not about getting one right answer.

- Explain what you liked about reaching a decision on a service learning project.
- Describe any challenges you had in the planning process.
- Share how your group reached decisions. Describe any challenges. 3
- Discuss how your group worked together as a team.
- Describe other information you believe you need to embark upon this project.

Science and Engineering Practices
Encourage youth by noting that they are using the Practices of Science and Engineering by 'Designing solutions' to problems they've identified.'

2 SciGirls

Support as they investigate using STEM practices

3 SciGirls

Embrace struggle, overcome challenges, and increase self-confidence in STEM

Activity B

Service into Action-Implementing your project

Facilitator Tip
Be sure to take pictures or video during the service project or designate a youth or adult to be the photographer.

OPENING QUESTIONS AND PROMPTS

- Describe how you feel about starting the project.
- Explain what you hope to gain and learn from this experience.
- Describe what type of support you expect or need from your adult facilitator.

PROCEDURE: COMPLETE THE ACTIVITY

1. Complete the service activity as planned. During their experience, they should keep a record of their progress and any challenges they encounter.

Facilitator Tip
Youth may be tired from the activity. It is recommended to keep this discussion to 15 to 20 minutes. Be sure to capture the reflections.

SHARE/PROCESS/GENERALIZE

When the service activity is complete, gather youth for a large group guided reflection on what the group accomplished and the impact they had. Help guide youth as they question, share, and compare their observations. 2 You may choose one of the questions below as a prompt. If necessary, use more targeted questions as prompts to get to particular points. Remember these questions are not about getting one right answer.

- Describe your favorite part of the service learning project.
- Explain the difference you believe you made in your school/community.
- Discuss the most difficult/challenging part of your service learning project.
- Describe things you learned from this service learning project that you believe will help you with other service learning efforts.
- Describe changes, if any, you would make to this service learning project if you were to do it again.

2 SciGirls

Support as they investigate using STEM practices

Activity C

Evaluating and Celebrating (60-90 minutes)

Youth will likely have discovered new perceptions of themselves and the world. They need to evaluate the outcomes and impacts of the planned process, along with determining possible modifications. Celebrating provides an opportunity to publicly recognize positive achievements and personal growth of youth. In addition, youth gain important presentation skills as they share their service learning project. This activity also offers youth an opportunity to share the impact of their service learning experience and to recognize their positive contributions to their community.

Facilitator Tip
If your program allows for two sessions for evaluating and celebration, you may plan to spend the first session guiding in-depth assessment (individual or group) of the project. The second session would be dedicated to the celebration and public showcase of what youth learned and accomplished during the service project. If your program is limited to one session, facilitators can adjust the depth to fit the time available.

Experience A: Evaluating (15-30 minutes)

OPENING QUESTIONS AND PROMPTS

- Discuss aspects of your service learning project that you think went well.
- Explain the project's strong points and weak points, and identify any areas that you believe needed improvement.

PROCEDURE

1. Allow time for youth to individually reflect on the completed Project Evaluation Form (Appendix D). The evaluation form can include writing, pictures, charts, or other expressions that assess the impact of the project.

Facilitator Tip
Have youth share their evaluation with the others in their group and share with other groups.

- Discuss the differences and similarities you find in your evaluations.
- How did your work benefit yourself? Others? 5
- Overall, in your opinion, how successful was the project and what made it successful?

2. Create a group reflection project to share through a visual presentation:
   - **Collage Option**: Youth may draw a picture or write a word that makes them think of their project, and each individual creation may be combined to form a group collage.
   - **Tri Fold/Poster or Digital Slide Option**: Youth can create a poster or digital slide presentation to share during the celebration. **This option can be started in small groups during the reflection session and completed later for future presentations at club or other meetings.

Science and Engineering Practices
Note that sharing about your project is the Science and Engineering Practice of 'Communicating Information.'

5 SciGirls
STEM is collaborative, social, and community-oriented

Experience B:
Celebrating (45-60 minutes)

Facilitator Tip
If time is limited to one session, you may want to pre-plan the celebration prior to Activity B.

PROCEDURE

Pre-Celebration

1. Have the facilitator and youth prepare an "open house" to share their project with others (family, teachers, community members, or other program youth). Determine the date and time.
2. Invite family members, volunteers, and community members to the service learning celebration.
3. Create a celebration event schedule. Allow time for youth to publicly share their learning in either small groups or in the larger group.

During Celebration

1. Display or project photos from the project for guests to see. Display reflection forms around the room or project area.
2. Youth share their reflections with guests and talk about their project.

Post-Celebration

1. If the group meets again after the showcase/celebration, the facilitator can engage the youth in an evaluation/reflection of how they felt their showcase went.

Facilitator Tip
For some youth, speaking with, or presenting to a large group may be a new experience. Facilitator may want to recognize the skills each youth exhibited during the showcase, including such things as speaking clearly, answering questions, overcoming feelings of nervousness, collaborating with their group members, or other.

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Appendix A

Facilitator Tip Sheet

1. **Leading discussions**
    - Use open-ended questions to generate rich discussion and a variety of responses.
    - Intentionally include quieter voices to offer opinions and participate.
    - Be ready for differing opinions and possible lively debate.
2. **Youth Voice and Choice**
    - Encourage all youth to share their ideas and make final selections from the collection of their ideas. The opportunity for youth to use thinking, initiative, and problem solving as they exhibit responsibility and decision making in an environment safe enough to allow them to make mistakes and still succeed.
    - Use questions to guide youth to think about potential outcomes in order to make the best decisions (e.g. "If we do this option, what will be the outcome?")
3. **Autonomy, Competence, Relatedness**
    - Self Determination Theory (Ryan & Deci, 2000) supports the adoption of a prosocial mindset and intrinsic behavior when the following elements are present in the service learning experience:
        - Autonomy: youth making the project choices
        - Competence: youth gaining and demonstrating skills
        - Relatedness: connecting the project to the greater community and world.
4. **Supporting Collaboration (group mission; individual accountability)**
    - Each participant has a role to play and is an important contributor to the project.
    - Help youth understand partnership and shared responsibility.
    - As a result, each participant should be sure to fulfill their commitment to the project and the group.
5. **Managing Conflict**
    - Lively debate may turn into conflict. Remind youth that not everything can be accomplished in one project. Societal and community problems can be big, and may need many people and many projects over time.
    - With younger youth, a completely objective method of decision making can be the best choice, such as the toss of a coin or "rock, paper, scissors."

Appendix B

Selecting a Project

Here are some questions to consider:

- What is the most important issue or need we want to help solve?
- How do we know this is a problem or issue? (what data do we have?)
- How can we share what we learned to help solve the problem?
- What do we want to learn during our service learning project?
- What do we want to accomplish in our service learning project?

PROJECT IDEAS

OUR PROJECT RECOMMENDATION IS…

WHY DO WE WANT TO DO THIS PROJECT?

Appendix C

Project Planning Tool

Project Plan

After you have selected a strategy for solving a community issue, you will need to develop a detailed project plan. The plan will outline all the tasks that need to be done, who will do them, and when they will be accomplished.

- Identify specific tasks to be accomplished in order to address your community problem.
- Decide when, and in what order, each task needs to be done. Make sure that you give enough time for each task.
- Decide who will be the team leader for each task. Volunteer for specific duties and stick to your commitments.

PROJECT NAME	
PROJECT GOAL	
DATE(S) OF SERVICE	

WHAT ARE WE PLANNING TO DO? (ACTION STEPS)	WHO IS RESPONSIBLE?	DATE TO BE COMPLETED	FOLLOW-UP NEEDED

Appendix D

Project Evaluation

Service Project Title: ________________________________Name____________________

Explain how your project met the needs of our school or community.	What difference do you think you made for your school/community?
Describe how you applied what you learned in the Polymer Science curriculum to your service learning project.	If you were going to do this project again, what would you do differently? Explain how you collaborated with other groups, individuals, or organizations.
Describe what you learned in the service learning project.	How, in your opinion, could you adapt your project in the future to make it even more impactful? How might your school/community continue parts of the service project?

Appendix E

Service Learning Model Overview

An effective, integrated service learning project provides the opportunity for youth to learn skills while filling real, recognized, and community needs. Youth experience challenges appropriate to their developmental level and are given the opportunity to demonstrate responsibility, decision making, and leadership within a collaborative environment (Berger Kaye, 2004). The well guided service learning experience can also help youth develop civic minded attitudes toward volunteering, voting, and staying connected to their communities throughout their lifetimes (Richards, et al., 2013).

This service learning model is an adaptation of two models (Berger-Kay, 2004; RMC Research Corporation, 2009) and California State 4-H recommendations. The model has four components:

1. Preparing (Pre-Service Planning)
2. Performing/Implementing/Doing
3. Reflecting
4. Sharing/Telling & Celebrating

Executing the service learning project may take three to six meetings, depending on the ages of the youth and the complexity of the project.

Service Learning Model Outline

1. Preparing (Pre-Service Planning)
    - Investigate a Need or Issue
        - Brainstorming
        - Collect relevant information
        - Choose a project
        - Select a goal

    Continued on next page

Appendix E

Service Learning Model Overview (Continued)

- Plan the Service Activity
    - Outline details in a project plan
    - Assign/select key roles
    - Create a project timeline
    - Engage partners or community in the service learning
    - Communicate project details

2. Performing/Implementing/Doing
    - Engage fully in service activities
    - Observe the impact of the project on different youth
3. Reflecting
    - Evaluate the learning and results (what went well? Lessons learned?)
    - Review the experience from a personal level.
4. Telling/Sharing & Celebrating
    - Tell your story; share it with others
        - Prepare a presentation for a parent showcase, club meeting, or Presentation Day event.
        - Write an article for a school, 4-H Club, or 4-H County newsletter.
        - Send a press release to a local newspaper.
        - Create a photo journal.
    - Celebrate the group's accomplishments

The SciGirls Strategies

Proven Strategies for Engaging Girls in STEM

The **SciGirls** approach is rooted in research about how to engage girls in STEM. A quarter of a century of studies have converged on a set of common strategies that work, and they have become the framework for **SciGirls**. The original set of strategies, created in 2010, were updated in 2019 to reflect current research.

1

Connect STEM experiences to girls' lives.

(Boucheretal.,2017;Sammetetal.,2016;Bonner&Dornerich,2016;Ereteetal.,2016;Stewart-Gardineretal.,2013;Civil,2016;Verdinetal.,2016;Cervantes-Soon,2016).

Make STEM real and meaningful by engaging girls in activities that draw on their interests, knowledge, skills, culture, and lived experiences. This helps girls develop a STEM identity and increases their sense of belonging in STEM.

2

Support girls as they investigate questions and solve problems using STEM practices.

(Buckholz et al., 2014; Kim, 2016; Scott & White, 2013; Farland-Smith, 2016; Munley & Rossiter, 2013; Civil, 2016; Riedinger et al., 2016)

Engage girls in hands-on, inquiry-based STEM experiences that incorporate practices used by STEM professionals. Let girls take ownership of their own STEM learning and engage in meaningful STEM work to positively impact their identities and re-define how they see STEM.

3

Empower girls to embrace struggle, overcome challenges, and increase self-confidence in STEM.

(Blackwell et al., 2007; Dweck, 2000; Halpern et al., 2007; Kim et al., 2007; Mueller & Dweck, 1998)

Help girls focus on and value the process of learning by supporting their strategies for problem solving and letting them know their skills can improve through practice. Support girls to develop a growth mindset—the belief that intelligence can develop with effort and learning.

4

Encourage girls to identify and challenge STEM stereotypes.

(Allenetal.,2017;Carlietal.,2016;Cheryanetal,2015;Robnett,2016;Allenetal.,2017;Carloneetal.,2015;Sammetetal.,2016,Scottetal.,2014;Tanetal.,2013;Dasguptaetal.,2014;Verdin et al., 2016; Civil, 2016; Boucher et al., 2017)

Support girls in pushing against existing stereotypes and the need to conform to gender roles. Helping girls make connections between their unique cultural and social backgrounds and STEM disciplines will negate potential stereotype barriers.

5

Emphasize that STEM is collaborative, social, and community-oriented.

(Capobiancoetal.,2015;Diekmanetal.,2015;Leaper,2015;Riedingeretal.,2016;Robnett,2013;Parker&Rennie,2002;Scantlebury&Baker,2007;Werner&Denner,2009;Cakiretal.,2017; Sammet et al., 2016; Boucher et al., 2017; Clark et al., 2016; Leaper, 2015)

Highlight the social nature of STEM to increase interest and motivation and change the stereotypical perception that STEM jobs require people to work alone. Girls benefit from a supportive environment that offers opportunities to build relationships and form a collective identity.

6

Provide opportunities for girls to interact with and learn from diverse STEM role models.

(Kochetal.,2015;Leaper,2015;Adamsetal.,2014;Jethwanietal.,2017;Kessels,2014;O'Brienetal.,2016;Levineetal.,2015;Hughesetal.,2013;Cheryanetal.,2015;Weisgram&Diekman,2017)

Introduce girls to diverse women role models from varied STEM career pathways to help girls see potential futures and develop resilient STEM identities. Positive role models can increase girls' interests in, positive attitudes toward, and identification with STEM.

Send us your Feedback!

Have you tried one (or more!) of the activities? Let us know how it went! We work with the Center for Applied Research and Education Improvement at the University of Minnesota to evaluate this project. Click on the button below to fill out their short evaluation form and help us collect valuable feedback for improvement!

4hpolymers.org/evaluation