NATIONAL
PEER REVIEWED

GRADES
6-8

Sustainable Polymers

Taking Action to Solve the Challenge of Plastics

A 4-H STEM Curriculum for Grades 6-8

National Science Foundation

NSF Center for Sustainable Polymers

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FRONT MATTER

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Sustainable Polymers

Taking Action to Solve the Challenge of Plastics

A 4-H STEM Curriculum for Grades 6-8

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4-H Polymer Science Curriculum for

Grades 6-8

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 note where the science and engineering practices are used. 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.

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

Sustainable Polymers: Taking Action to Solve the Challenge of Plastics is a youth-driven curriculum focusing on the use and impacts of plastics and sustainability. 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 three learning phases/modules intended for delivery in out-of-school time facilitated by an educator (trained volunteers or program staff). In each phase, youth will explore polymer science content through a guided activity and then become change agents through youth-driven projects.

CURRICULUM TARGET AUDIENCE

Youth in grades 6-8 (11 to 14 year olds)

DEVELOPED BY

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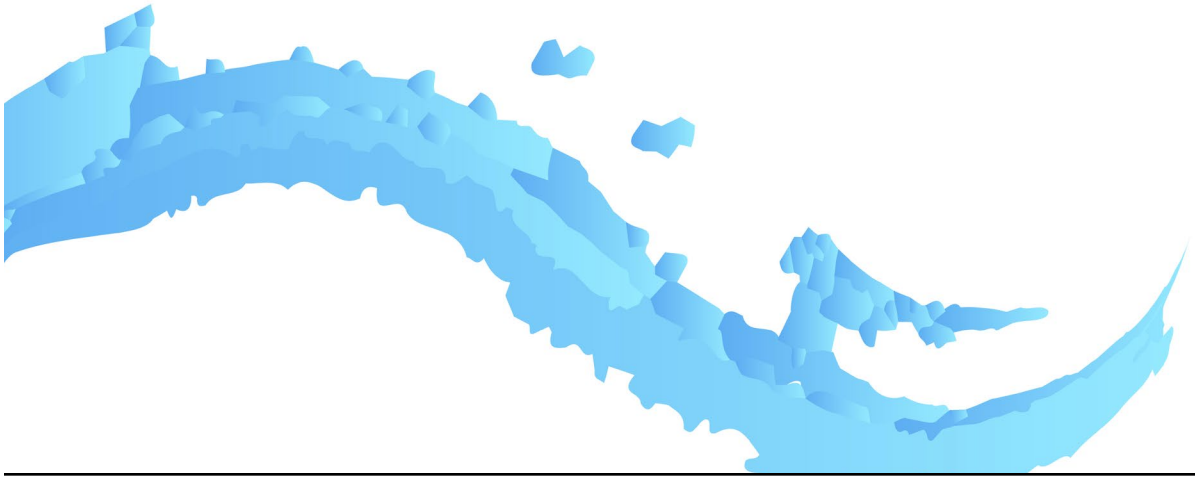

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INDIVIDUAL MODULE CITATIONS

- McCambridge, J., & Worker, S. (2020). Front Matter. In J. McCambridge, A. Mondl, A. Stevenson, & S. Worker (Eds.). *Sustainable polymers: Taking action to solve the challenge of plastics. A 4-H STEM curriculum for Grades 6-8.* NSF Center for Sustainable Polymers. University of Minnesota. https://www.4hpolymers.org/
- Worker, S., Panero, A., Cappa, A. Meehan, C., & Smith, M. (2020). The Plastic Past: Rise of the World's Most Popular Material. In J. McCambridge, A. Mondl, A. Stevenson, & S. Worker (Eds.). *Sustainable polymers: Taking action to solve the challenge of plastics. A 4-H STEM curriculum for Grades 6-8.* NSF Center for Sustainable Polymers. University of Minnesota. https://www.4hpolymers.org/
- Maille, A., & Malone, C. (2020). The Plastic Present: Inescapable Impacts of Polymers. In J. McCambridge, A. Mondl, A. Stevenson, & S. Worker (Eds.). *Sustainable polymers: Taking action to solve the challenge of plastics. A 4-H STEM curriculum for Grades 6-8.* NSF Center for Sustainable Polymers. University of Minnesota. https://www.4hpolymers.org/
- Mondl, A., Stevenson, A., & McCambridge, J. (2020). The Plastic Future: Search for Alternatives and Renewables.In J. McCambridge, A. Mondl, A. Stevenson, & S. Worker (Eds.). *Sustainable polymers: Taking action to solve the challenge of plastics. A 4-H STEM curriculum for Grades 6-8.* NSF Center for Sustainable Polymers. University of Minnesota. https://www.4hpolymers.org/

LEARNING OBJECTIVES SUMMARY

In this set of three modules, youth will explore concepts in sustainability and take positive action as change agents around a plastic issue impacting their communities. Youth will learn about the different types and uses of plastics, and explore the many benefits and challenges plastic can have on humans, animals, and the environment. Youth will gain polymer science content knowledge to understand how complex systems interact. They will discover and practice the skills used by scientists and engineers to learn about materials and their properties. Through their learning, youth will make informed decisions and work as change agents who actively contribute to the sustained health of their communities and environment.

MODULE SUMMARIES

1. The Plastic Past: Rise of the World's Most Popular Material
   Youth will prepare a marketing pitch to a beverage company for a container made from different types of materials using scientific information and life cycle analysis.

2. The Plastic Present: Inescapable Impacts of Polymers
   Youth will determine how disposal choices of plastics impact the environment through a human-sized board game.

3. The Plastic Future: Search for Alternatives and Renewables
   Youth will discover strategies to sustain the creation of plastics when the supply of materials is variable through a simulation game. Youth will also create polymer water pods to explore future uses for polymers.

CONTENT SUMMARY — THE IMPACTS OF PLASTIC

The theme of these modules focuses 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 of 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 many uses. 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 8% 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. Sustainable polymers must address the needs of consumers without damaging our environment, health, or economy.

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 provides valuable benefits in knowledge, skills, and interests, and also in the form of 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:

- Establish a safe environment and build 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 PROMOTING 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 incorporating 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 guided 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

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, facilitate a group discussion to get youth thinking about what they know about the main learning objectives of the module.
- **Experiencing**: Provide 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 learning 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 where they will use what they learned. In this curriculum, the "Youth as Change Agents" serves an application for the polymer exploration activities.

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 close-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 in 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.

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 incorporate many of the science and engineering practices identified in the Next Generation Science Standards. Youth in grades 6-8 will work on their skills in these practices.

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 modules. These core ideas span the physical sciences (PS), life sciences (LS), earth and space sciences (ESS), and engineering, technology, and the applications of science (ETS).

Disciplinary Core Ideas:

1. Chemical Reactions (PS1.B)
    - Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants.
2. Biodiversity and Humans (LS4.D)
    - Changes in biodiversity can influence humans' resources, such as food, energy, and medicines, as well as ecosystem services that humans rely on—for example, water purification and recycling.
3. Natural Resources (ESS3.A)
    - Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. Minerals, freshwater, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes.

4. Human Impacts on Earth Systems (ESS3.C)

    - Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things.

    - Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.

5. Defining and Delimiting Engineering Problems (ETS1.A)

    - The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions.

6. Developing Possible Solutions (ETS1.B)

    - A solution needs to be tested, and then modified on the basis of the test results, in order to improve it.

    - There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem.

    - Models of all kinds are important for testing solutions.

7. Optimizing the Design Solution (ETS1.C)

    - Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design.

    - The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution.

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

Crosscutting Concepts:

1. Patterns

    - Graphs, charts, and images can be used to identify patterns in data.

2. Structure and Function

    - Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used.

- Cause and effect relationships are routinely identified, tested, and used to explain change.

3. Interdependence of Science, Engineering, and Technology
    - Engineering advances have led to important discoveries in virtually every field of science, and scientific discoveries have led to the development of entire industries and engineered systems.
4. Influence of Engineering, Technology, and Science, on Society and the Natural World
    - All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment.
    - The uses of technologies and any limitation on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time.
5. Science Addresses Questions About the Natural and Material World
    - Scientific knowledge can describe the consequences of actions but does not necessarily prescribe the decisions that society takes.

Together, the practices, core ideas, and crosscutting concepts covered through these modules mirror a number of performance expectations for youth in grades 6-8, such as:

- Gather and make sense of information to describe that synthetic materials come from natural resources and impact society (MS-PS1-3).
- Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment (MS-ESS3-3).
- Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems (MS-ESS-4).

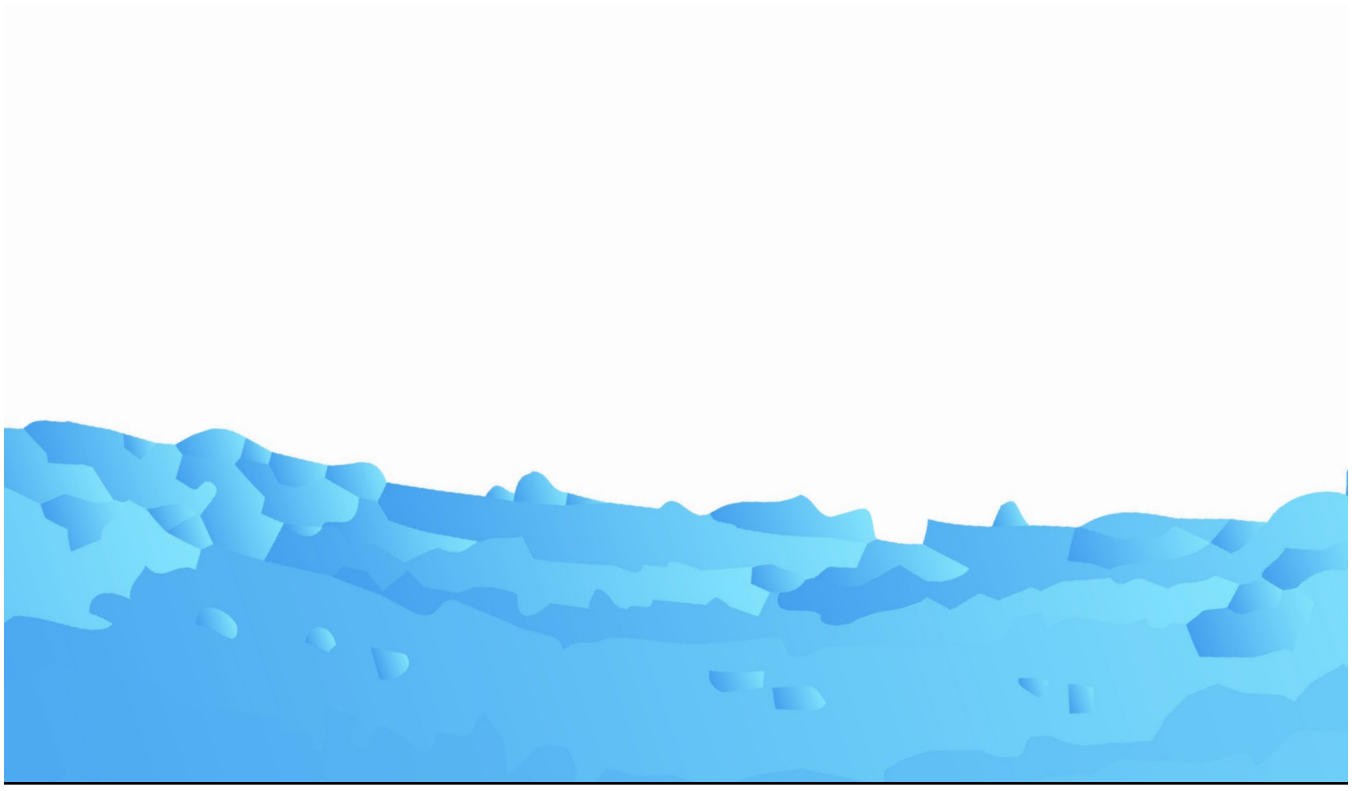
Facilitator Tools

Tips for Facilitating Group Discussions

Facilitators play an important role in guiding youth through the process of discussion and setting goals collaboratively. Begin creating a safe and supportive environment by using these group facilitation strategies:

1. Welcome youth.
2. Begin with an opening activity/energizer/icebreaker that helps create connection, a sense of belonging, and teamwork with youth in preparation for group discussion.
3. Create shared agreements with youth to collaboratively build an environment that supports open discussions and shared decision making. Here are some potential agreements that support a positive discussion:
    - Respect
    - Open communication - active listening, open sharing
    - Everyone has the opportunity to contribute ideas and take a leadership role with responsibilities.
    - Adults and youth share decisions making
    - Shared Investment - each member plays an important role in planning and working toward the desired outcomes. This leads to a sense of shared ownership and belonging.
4. Cultivate Youth Voice
    - Encourage youth to come up with ideas and share their perspective.
    - Encourage other points of view - no idea is a bad idea, ask for clarification.
    - Intentionally include quieter voices to offer opinions and participate.
5. Lead discussion using a variety of active discussion methods to engage youth (examples are included in the Examples of Active Discussion Methods section).

6. Support Collaboration (group mission; individual accountability)
    - Each participant 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.
7. Manage Conflict
    - Lively debate may turn into disagreements. Help youth understand different points of view. Suggest phrases that youth can use to acknowledge the other point of view, even if they disagree with the statement. Phrases can include: "It's okay that we have different opinions on this," "Let's give each person a chance to share their opinion," or "Let's listen to understand what they are saying, not just to respond."
    - With younger youth, an objective method of decision making can be the best choice, such as the toss of a coin or "rock, paper, scissors."
8. Provide positive and concrete feedback
    - Acknowledge the assets, contributions, and commitment that youth dedicate to the project as well as their unique leadership skills
    - Offer specific feedback unique to the young person that encourages a growth mindset. For example, "I have seen how hard you have worked and how your persistence has made an impact on the project."



DISCUSSION WARM-UP EXAMPLES

The following warm-ups can be used to help get youth moving and connected around plastic related issues:

- **Matter of Opinion** - Create a series of statements regarding plastics and ask youth to line up based on their opinion regarding the statement using strongly agree at one end and strongly disagree at the other end. For example, use the statement "I believe plastics can be both useful and good for the environment." After youth have moved to the spot on the line that best presents their opinion, ask a few youth to volunteer to share their opinion with the larger group. This can also be expanded to four corners of the room with each corner discussing the statement. Pictures of plastics can be used to begin the conversation.
- **Photo of Mine** - This activity is geared to start exploring the issue, especially if youth are shy and hesitant to talk. Offer a range of photos related to plastics. Ask youth to choose a photo that strikes them. Once they have a photo, ask them to find a partner with a different photo. The pair then discuss the image and image meaning. Provide time for group sharing.
- **Knee to Knee** - Create two lines, each with equal numbers of youth facing each other. Provide a question or statement related to plastics. For example, "Can all plastics be recycled?" Give one minute for the pair to discuss the topic. After one minute, call for the group to switch with one line moving one person over to right. Then pose a second plastic related question. Continue for as many rounds as best works for the group. Ask youth to share important elements or thoughts from the conversations.
- **Ball Toss** - Ask youth to make a large circle. Use a ball (larger than a tennis ball) and ask students to toss the ball and share one question or belief related to plastics. Make sure all participants get a chance to toss the ball and share.
- **I Wonder** - Provide youth with a half sheet of paper or an index card. Ask students to write one thing they wonder about plastics (our use, the impact on the environment, or sustainability). Ask the students to place their paper or index card in a central pile once they are finished recording the thing they wonder. Next, ask students to take a different paper or index card and read out loud to the group.
- **Rose and a Thorn** - Ask youth to find a partner and ask them to share one "rose" or positive thing about plastics and one "thorn" or negative thing about plastics. After one minute of sharing, ask a few students to volunteer to share some examples of a rose and thorn. Facilitators can also play music as youth move, then when the music stops, youth can find a different partner to share.

DISCUSSION METHOD EXAMPLES

The following examples of discussion methods can be used to ensure all voice are heard, youth are working as a team to generate ideas, and creating innovative solutions together:

- **Rapid Post-It Brainstorm** - Provide a range of small color Post-It pads to students. Give students two minutes to write any plastic issue they can think of or may want to solve. Ask that they don't write solutions yet, but to focus on quickly listing the issues. After two minutes, ask students to post their notes on a board in front of the group. After the notes are posted, ask one youth to read notes and help identify themes. Choose the top 2-3 themes and lead a second round of two-minute rapid brainstorming focusing on potential solutions. Ask youth to post potential solutions. Ask one youth to read all the solution Post-Its and help identify themes. Discuss as a large group the most common plastic related issue and most common plastic related solution.
- **Rotation Brainstorm** - Around a room, post a designated number of poster papers each with a different topic heading, a statement, or a question related to a plastic issue (our use, the impact on the environment, or sustainability). Ask youth to visit one poster paper to add at least one thought or suggestion. After a designated amount of time (2-3 minutes), the facilitator calls "switch" for the youth to rotate to a different poster. Be sure everyone has an opportunity to contribute to each poster. Youth can switch as a group or move to the next poster in a different group. After youth have finished, a youth or facilitator reads from the posters. Discuss themes and suggestions as a large group.
- **Think-Pair-Share** - Provide youth with an article, a video, or interesting plastic items to review or consider. Group youth into pairs to share insights and discuss. After three minutes, ask for volunteers to share important points from the discussion.
- **Small-Group Rotation** - Create a set of 3-4 different questions or statements related to plastics (our use, the impact on the environment, or sustainability) and list each question on a different poster paper. Station one poster paper at each table. Divide youth into 3-4 groups. Each group will have five minutes at a table to discuss a specific question. Ask one youth to record discussions. After five minutes, ask the youth to visit a different table to discuss. Have enough rotations so participants can visit each question or statement. After all the rotations are complete, ask someone from each table to share insights from the poster recordings.
- **Know and Want to Know** - Create two posters 1) What do we know about plastics and 2) What do we want to know about plastics. Post the paper and ask youth to visit each poster and record thoughts. After brainstorming, ask for a volunteer to read from the posters. As a group, identify themes.
- **Twenty Questions** - Ask youth to work with a partner to brainstorm 20 questions they have related to plastics (our use, the impact on the environment, or sustainability). Ask youth to share their list of questions. Identify the top five common questions to explore. As a large group, select the question the group is most interested in finding the answers.

Youth As Change Agents

CORE LEARNING EXPERIENCES

In each module, youth will have the opportunity to work as change agents in their local communities. Youth will design a project to address the driving questions related to plastics and sustainability. As youth explore and develop their projects, they will go through common learning experiences:

1. **Discovering the action project**
    - Ask questions and discuss issues related to plastics
    - Brainstorm/ generate ideas for a project/plan to address the issue
    - Record ideas
    - Identify what additional information is needed to select a project/plan
    - Determine ways to address/solve the issue
    - Identify how the project will make a positive change
    - Select a project
2. **Planning the action project**
    - Discuss and determine project goals
    - Identify resources
    - Create action steps/data collection plan to guide the project
    - Determine who will do what by when
3. **Putting the plan into action**
    - Implement action plan
    - Analyze the project's impact
    - Share project impact/project research
    - Determine project sustainability
4. **Sharing and reflecting on the action project**
    - Evaluate the project
    - Reflect on personal learning
    - Publicly showcase the project
    - Share results with community
    - Celebrate project impacts and personal contributions

CHANGE AGENT APPROACH MATRIX

There are several inquiry-based approaches that can be used when guiding youth through developing and implementing an action project around a plastic issue. The Change Agent Approach Matrix can help determine the approach that best fits the action question youth want to address. Examples are provided for each approach.

APPROACH DEFINITIONS	APPROACH PROCEDURES (FULL LEARNING CYCLE)	APPROACH EXAMPLES	SAMPLE QUESTIONS
Citizen/Community Science Youth work with scientists to collect data used to study real-world phenomena, or youth report data to a database or program which supports the work of professional scientists Program Model Example: for programs delivered at or near natural resources locations, such as park facilities, nature centers, and have direct connection with scientists and field experts	**Citizen/Community Science** Discover your research question • Identify experts or current research on your plastic issues • Determine how your project might fit with other plastic-focused projects • Create your data collection plan • Collect & analyze your data • Share findings • **Resources**: https://scistarter.org/ and https://www.citizenscience.gov/#	**Citizen/Community Science** Volunteers study ocean debris washed ashore and team up with a local university to study how the currents move debris through the water. https://www.frostscience.org/marine-debris/ Community members collect data on the microplastics in their coastal areas. https://microplasticsurvey.org/	**Citizen/Community Science** How much litter in or near our waterways are plastics? What is the most common type of plastic litter in our community? How much plastic is recycled in our community each month? What current plastic related research is happening in our community (at nature centers, education institutions, city/county government)? Who are the scientists working on plastic issues in our community or world?

APPROACH DEFINITIONS	APPROACH PROCEDURES (FULL LEARNING CYCLE)	APPROACH EXAMPLES	SAMPLE QUESTIONS
Geo-inquiry Youth analyze space, place, and human conditions through maps usually with the aid of geographic information systems (GIS). Program Model Example: for programs delivered at sites with access to GIS technologies, such as college campuses, scientific facilities, libraries, etc.	**Geo-inquiry** • Discover your question around plastics • Research your plastic topic • Identify resources (community experts, organizations) • Determine what and how you will collect data (survey, interview, observations, videos) • Analyze and map your data: how is the data connected; what visuals can show connections • Develop a geo-inquiry story: outline geo-inquiry • Create storyboard • Determine multimedia approach • **Resources**: https://www.nationalgeographic.org/education/programs/geo-inquiry/	**Geo-Inquiry Example** Students in Kansas City, Missouri learned about their local watershed. While collecting water quality samples the students noticed a large amount of plastic trash. This observation led the students to explore how they were impacting the local watershed with solid waste and what they could do about it. https://www.arcgis.com/apps/Cascade/index	**Geo-Inquiry** Where does the plastic pollution in our river come from and how can we educate our community about these problems? Where is plastic pollution coming from in our community? What might be an explanation for this plastic pollution? What places of business generate the most single-use plastics in our community? Where is plastic pollution impacting our watershed the most?

APPROACH DEFINITIONS	APPROACH PROCEDURES (FULL LEARNING CYCLE)	APPROACH EXAMPLES	SAMPLE QUESTIONS
Community Engagement Youth get involved in an organized effort on behalf of another government or nonprofit organization to benefit the community. Program Model Example: for programs delivered in partnership with a local neighborhood, community, or shared issue	**Community Engagement** Discover the plastic issue within your community • Research what is happening in your community • Interview community members, officials, etc. about the plastic issue • Collaborate with government and businesses • Identify project partners and community resources (e.g. school principal) • Create an action plan • Implement community action plan/advocacy plan • Analyze and publicly share impact • Resources: https://digitalcommons.unomaha.edu/cgi/viewcontent.	**Community Engagement** In response to the amount of waste New York City public schools were throwing away with styrofoam trays, the organization Cafeteria Culture worked to eliminate these foam trays from all NYC lunchrooms. Youth take on leadership roles as Cafeteria Rangers to assist with correct garbage sorting at their schools. http://www.cafeteriaculture.org/our-story.html Reduce School Lunch Waste resources from the US Environmental Protection Agency https://www.epa.gov/students/pack-waste-free-lunch	**Community Engagement** What concerns do youth and adults have about plastics in our community? How might we advocate for our community to stop using plastic straws and other one-use plastic items? What approach might be successful to change the way our school, community, and businesses discard plastic waste? What does our community need to know about plastic recycling?

APPROACH DEFINITIONS	APPROACH PROCEDURES (FULL LEARNING CYCLE)	APPROACH EXAMPLES	SAMPLE QUESTIONS
Service-learning Youth develop a project to benefit others and their community. Service-learning is a direct-service, indirect service, or advocacy-based service project that does not include data collection. Program Model Example: for programs delivered in partnership with a local neighborhood, community, or shared issue	**Service learning** • Discover the plastic issue you want to address • Research the plastic issue • Determine the best project to address the plastic issue • Plan the service action plan - who will do what, when, and where • Secure needed resources or partners (people, materials) • Implement service plan • Reflect on learning through focused activities (personal learning and how it is related to broader learning/experiences) • Identify and share project impacts and if applicable sustainability Resources:	**Service Learning** Youth from Indiana Public School # 91 created Zero Waste Free Cafeteria from a service learning grant they received to address school waste. They worked with Earth Charter Indiana to create a project that resulted in 75% reduction in school waste. Upcycle Plastics into Art - Combine your desire to make positive change with your artistic spirit by upcycling plastics into art!	**Service Learning** What should we do to teach others to reuse a plastic bottle instead of throwing it away? How can we create a school recycling program? Where do we see plastic litter in our neighborhood? What can we do to help clean it up and prevent future waste from collecting here? What challenges do local recyclers face with recycling plastics?

APPROACH DEFINITIONS	APPROACH PROCEDURES (FULL LEARNING CYCLE)	APPROACH EXAMPLES	SAMPLE QUESTIONS
Youth participatory action research (YPAR) Youth define an issue and research question, conduct an investigation (data collection, analysis), and then take action based on the results. In YPAR, youth develop a project where they collect and analyze data, followed by a service-learning project informed by their data outcomes. Program Model Example: for programs delivered with stakeholder observation and involvement	**Youth participatory action research (YPAR)** • Discover the plastic issue • Explore how the issue impacts you/your community • Develop your research question and data collection methods • Identify strengths, resources, and stakeholders • Collect and analyze data • Determine what change do you want to see • Identify who needs to know (local governments, businesses, schools, policymakers, etc.) • Create a plan to share the information, evaluate impact, determine sustainability • Resources: http://yparhub.berkeley.edu/	**Youth participatory action research (YPAR)** Youth design investigation to learn about how plastics in their community get into the watershed. Then they use what they learned to involve their community in reducing the amount of plastics that get into the watershed. Youth wondered what their classmates thought about recycling. So they posed a research question: How important do middle school students think it is to recycle plastic, aluminum, and glass? What helps or hinders them in recycling? They designed a survey with the help of their teacher, and collected 125 responses. They analyzed data and determined what their classmates thought. Students then embarked on an education and awareness campaign, and talked to their principal and custodian about reducing barriers to recycling.	**YPAR Sample** Authentic YPAR questions need to be created and driven by youth participants. Examples: How much plastic do we throw away each week in our classroom? What do people in our community remember about materials we used before plastics? How do our middle school classmates feel about recycling? What messages would work to convince our middle school classmates to switch to reusable beverage containers instead of one-use containers?

YOUTH AS CHANGE AGENTS-CORE LEARNING EXPERIENCES

As facilitators guide youth through the process of developing an action project, there are core learning experiences and guiding questions that are common across each inquiry-based approach. Facilitators will guide youth as they: 1) discover the action project, 2) plan the action project, 3) put the project into action, 4) share and reflect on the action project.

CORE LEARNING EXPERIENCES	GUIDING QUESTIONS
Discovering the Action Project • Youth ask questions and discuss issues related to plastics. • Youth brainstorm/ generate ideas for a project/plan to address the issue. • Youth record ideas. • Youth identify what additional information is needed to select a project/plan. • Youth determine ways to address/ solve the issue. • Youth will identify how the project will make a positive change. • Youth select a project.	**Discovering the Action Project** • What do we already know about plastics in our community/ in our world? • What do we wonder about plastic use and the environment? • What information do we need to know about plastics in our community or world (research)? • What critical issue related to plastic use and its environmental impacts do we want to address? • What action can we take to answer or address the question or issue? • How do the polymer science explorations influence how we want to take action?

CORE LEARNING EXPERIENCES	GUIDING QUESTIONS
Planning the Action Project • Youth discuss and determine project goals. • Youth identify resources. • Youth create action steps/data collection plan to guide the project. • Youth determine who will do what by when.	**Planning the Action Project** • What do we want to achieve in this project? • What skills do we need to accomplish this project? How could we gain them? Who can help? • Who can we invite to partner with us on planning the project (elected officials/government representatives, businesses, schools or non-profits)? • What steps do we need to take to achieve this goal? • What resources do we need to help us achieve our goal? • What is our timeline - which activities will we do when? • What are the roles for our group members (who will do what by when)? • What else do we need to know to help us be more prepared for this project?
Putting the Plan into Action • Youth implement an action plan. • Youth share project impact/project research. • Youth determine project sustainability.	**Putting the Plan into Action** • What final preparation steps do we need to take in order to implement the plan? • Are there additional people we can invite as we put the plan into action - peers, family members, community members, leaders, others? • How will we record what we did? • How will we share the results of our work? Is it already part of the project (for example, in a Citizen/Community Science project protocol)?

CORE LEARNING EXPERIENCES	GUIDING QUESTIONS
Sharing and Reflecting on the Action Project • Youth analyze and evaluate the project's impact. • Youth reflect on personal learning. • Youth publicly showcase the project. • Youth share results with community and stakeholders. • Youth celebrate project impact and personal contributions.	**Sharing and Reflecting on the Action Project** **Youth Learning:** • Why did we choose this project? • What did we accomplish? • What ways did we impact the plastic issue in our community/world? • Are there new questions or ideas? • If we were to do this project again, what would we do differently? • How might we or the community continue elements of the project? **Youth Leading:** • What did we learn? What skills did we gain? • What was our favorite part of the project? The hardest part? • How do we feel about what we accomplished in the project? • How do we feel about how our group worked together during the project? • What leadership skills did we gain through the project? **Celebrating:** • Who helped us along the way? How should we thank them? • Who else can help share our findings? How can they help us continue our efforts? • How can we all celebrate together?

Change Agent

1
PROJECT SELECTION TOOL

Here are some questions to consider:

- What is the most important plastic issue 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 action project?
- What do we want to accomplish in our action project?

PROJECT IDEAS

OUR PROJECT RECOMMENDATION IS...

WHY DO WE WANT TO DO THIS PROJECT?

Change Agent

2
PROJECT PLANNING TOOL

The Change Agent Project Planning Tool can be used when developing a detailed project plan to solve a plastic issue. The plan outline outlines 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 the plastic issue.
- ✓ 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

Change Agent

3
PROJECT EVALUATION

Action Project Title: _____Name_____

Explain how your project addressed an issue related to plastics.	**What difference do you think you made related to the challenge of plastics?**
Describe how you applied what you learned in the Polymer Science curriculum to your action 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 action project.	**How, in your opinion, could you adapt your project in the future to make it even more impactful?**

POLYMER SCIENCE EXPLORATION ACTIVITIES GRID

Find all activities at: 4hpolymers.org/polymerx

POLYMER SCIENCE ACTIVITY	ACTIVITY SUMMARY	THEME AND SUGGESTED CORRESPONDING MODULE
Cup Wars	In this activity, youth will explore different types of plastics, including petroleum-based and plant-based plastics. They will conduct a test to see how heat affects these different plastics.	**SCIENCE AND ENGINEERING IN SOCIETY** Module 3
Engineering Consultant Challenge	Youth become engineering consultants and work as a team to plan a group activity that promotes sustainable consumer decisions.	**SCIENCE AND ENGINEERING IN SOCIETY** Module 2
Polymer Scientist Change Agents	Youth will hear from polymer scientists at the NSF Center For Sustainable Polymers who are driven to address the environmental challenges that are inherently associated with traditional (petroleum-based) plastics.	**SCIENCE AND ENGINEERING IN SOCIETY** Module 3

POLYMER SCIENCE EXPLORATION ACTIVITIES GRID

Find all activities at: 4hpolymers.org/polymerx

POLYMER SCIENCE ACTIVITY	ACTIVITY SUMMARY	THEME AND SUGGESTED CORRESPONDING MODULE
Making Bioplastics	In this activity, youth will create their own bioplastic from cornstarch, vegetable oil, and water. Please note, a microwave is needed.	**SUSTAINABILITY** Module 3
Old Plastics into New Products	In this activity, youth fuse old plastic bags using an iron to create new products like bags, coasters, mats or rugs.	**SUSTAINABILITY** Module 3
Youth as Change Agents	Youth will learn about a wide range of young people and adults working to address the challenge of plastics. Suggested projects are also included.	**SUSTAINABILITY** Module 1
We're Going to a Beach Party	The goal of this activity is for youth to begin to explore the consequences of different material choices by deciding what kind of plates, forks, and eating utensils to bring to a party.	**IMPACTS OF PLASTICS** Module 2
Plastic Sculpture Challenge	The Plastic Sculpture Challenge includes 4 lessons to explore the world of plastics, including making an amazing piece of art by repurposing (upcycling) single use plastics, conducting a household plastic audit, learning about the Resin Identification Code (numbers) on plastic containers, and sharing learning. Groups can create a final showcase of the plastic sculptures created by youth.	**IMPACTS OF PLASTICS**
Lunch Time Waste Audit	Youth will conduct a lunch time waste audit to discover the most commonly discarded plastic lunch items. Then they will make recommendations on alternatives to the plastic lunch items.	**IMPACTS OF PLASTICS**

GRADE 6-8 GLOSSARY

- **Aluminum**: a silvery-white, lightweight non-magnetic metal.
- **Biodegradable**: capable of being decomposed by bacteria and other microorganisms
- **Bioplastic**: polymers often made from starch-containing plants, such as corn and potatoes. Many of these bioplastics are compostable.
- **Carbon footprint**: the amount of carbon dioxide produced due to the consumption of fossil fuels through human activities (e.g., transportation, electricity generation, agriculture, manufacturing).
- **Change agent**: youth leaders who transform their ideas into actionable projects to create positive social impact.
- **Disposal**: the action or process of throwing away or getting rid of something.
- **Glass**: a hard, brittle substance made from sand.
- **Industrial compost facility**: site where organic waste products go through a multi-step process converting items into usable soil.
- **Landfill**: site where waste from the community is taken.
- **Life cycle**: the extraction of raw materials; manufacturing of the product; the transportation of the product; the use of the product by the consumer; and the disposal or recovery of the product.
- **Life cycle assessment**: evaluates the environmental impacts of the extraction of raw materials; manufacturing of the product; the transportation of the product; the use of the product by the consumer; and the disposal or recovery of the product.
- **Litter**: items not disposed in recycling, compost, or trash receptacles are instead disposed of in the environment.
- **Microplastics**: tiny pieces of plastic.
- **Non-renewable resource**: 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 type of material made from polymers that can be molded into solid objects. Usually made from petroleum/oil.
- **Pollution**: contamination by waste, chemicals, or other harmful substances to an environment.
- **Polylactic acid (PLA)**: a specific type of bioplastic derived from plant materials, usually corn.

- **Polymers**: chemical compounds formed from long repeating chains of smaller molecules.
- **Recycle**: process of converting waste materials into new objects.
- **Refuse**: decline to use an item and identify alternatives.
- **Renewable resource**: resources that can be replenished, often within one person's lifetime.
- **Repurpose**: use an object for a new purpose other than it was originally intended.
- **Reuse**: find a way to use again; or sell/donate for another to use.
- **Trend**: a way of demonstrating change over time.
- **Single-use**: an item that is thrown away after being used only once.
- **Sustainable**: able to be maintained or run continuously with little to no negative impact on the environment or health.
- **Sustainable polymer**: a plastic material that addresses the needs of consumers without damaging our environment, health, and economy.