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Lesson 3: What is Plastic?

Description: An introduction to man-made polymers, both why they were created and how they are used.

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Upon completion of this lesson students will be able to:

Describe basic polymer structure and characteristics.

Concepts:

1. Plastics are polymers.
2. The scientific method is a useful tool for conducting experiments.
3. There are many different types of plastic.

Outcomes:

Upon completion of this lesson students will be able to:

1. Describe basic polymer structure and characteristics.
2. List the basic steps of the scientific method.
3. Describe the characteristics that make different types of plastic unique.

Outline:

I. Set up (10 min.)

II. Introduction (5 min.)
- a. Learner Level Assessment
- b. Behavior Guidelines

III. Creating a Polymer Activity (35 min.)
- a. Student Experiment
- b. Polymer Discussion

IV. Conclusion and Review (5 min.)

V. Follow-up Activities
- a. Research the Origin of Plastics
- b. Track the Changes in Your Created Products
- c. Plastics by the Numbers Sorting Activity

VI. Additional Resources
- a. Sources
- b. Vocabulary

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There are many examples of natural polymers including hair, spider silk, natural rubber, and DNA.

I. Set up (10 min.)

A projector and computer will be needed to show a few charts. You can also print these off if you prefer not to use a projector.

Materials:

- **Borax (found in the laundry section of the store)**
- **Cornstarch (found in the baking section of the store)**
- **White glue (e.g., Elmer's glue)**
- **Warm water**
- **Multiple sets of measuring spoons (ranging from 1/2 tsp. to 1 tbs.)**
- **Spoon or craft stick**
- **Dixie cups or other containers for mixing**
- **1 Cup measuring cup**

Set out cornstarch, glue, Borax, and water for student experiments. Arrange measuring devices, mixers, and mixing cups so that all student teams have access to them. Depending on the number of students in the class, it may be helpful to set up multiple ingredient stations in different areas in the room. Another option is to provide each student desk group with a set of materials.

I. Introduction (5 min.)

a. Learner Level Assessment

Simple definition of polymer (Provided by Merriam-Webster):
A chemical compound that is made of small molecules that are arranged in a simple repeating structure to form a larger molecule.

Polymers are all around us and always have been. Although we have been creating man made polymers for about the past 150 years, there are many examples of natural polymers including hair, spider silk, natural rubber, and DNA. Polymers are repeating chains of molecules and can be very durable and strong. Use strips of paper and a stapler to create a chain of paper loops while discussing polymers in order to create a visual. Discuss the fact that the paper would be the hydrocarbon in the case of plastic and the stapler would be the chemical introduced to chain it together.

Let the students know, "Today we have a science challenge! You will work in teams to replicate the creation of a product that can be made into almost anything!"

Background:
In the early 20th century, there was a race to discover new polymers. Scientist and inventors around the world were using new chemical extraction processes to try and create substances that would meet demands for products that were being created with very limited resources. At that time, ivory was being used for billiard balls and fancy combs were made from tortoise shell. Although fulfilling the demand for scarce products and making profit was often the goal, it was vital to the preservation of those species to find a suitable replacement for products based on their harvest. Plastic was to be that replacement. It could be made into any shape or color, it was durable, and it was cheap. Many combinations of chemicals were experimented with before the first plastics were successfully created.

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Use the scientific method to experimentally create various substances.

b. Behavior Guidelines

Some lessons and activities in this curriculum require tools and/or physical activity, so there may be a need to discuss behavior expectations before activities. For this lesson, students will be working with a variety of substances that while not toxic, have the ability to create a mess if spilled. Stress that students are scientists conducting an experiment and should treat their materials with respect. Measuring is especially important, and it may be necessary to give students a mini lesson on using measuring devices if they are not familiar. Stress respect for classmates, self, and their environment before the experiment phase of the lesson begins.

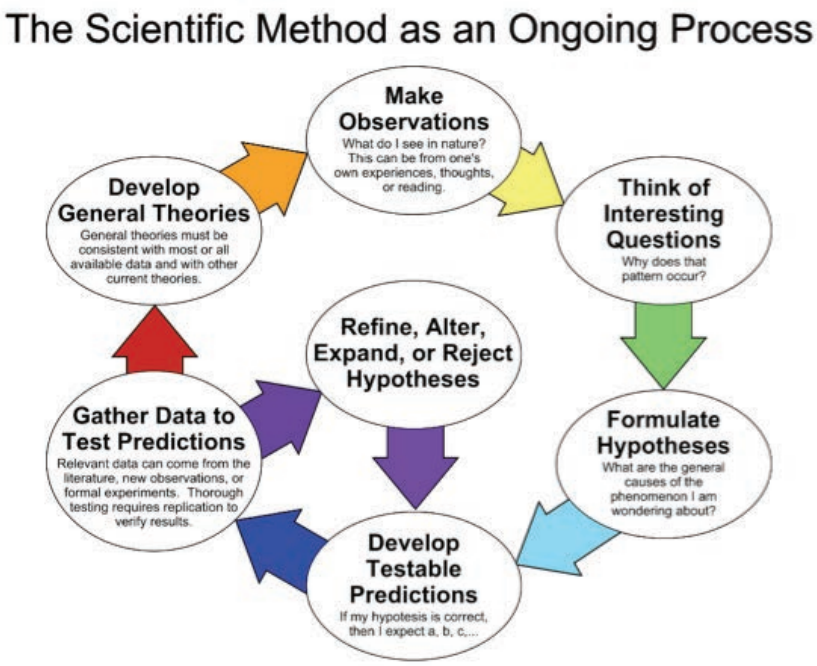
III. Creating a Polymer (35 min.)

a. Student Experiment

Pretend that you are scientists and inventors and that you must create a substance that can be formed into any shape, be made into any color, and last a long time. You have a good idea of what ingredients may be necessary to create what you'd like.

Instructions for students: "On the table you will find four substances, a few of which you might be familiar with. By combining a particular set of them, you can create a flexible and strong product. The amount of the substance will make a difference. You can use half a teaspoon to one tablespoon of any of them. You may not need all of them. The order they are combined may make a difference."

Have students use the scientific method to experimentally create various substances. Introduce the scientific method if students are not familiar with it.



Source: http://idea.ucr.edu/documents/flash/scientific_method/story.htm

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Polymers are made up of repeated patterns of molecules, called monomers.

Observe: (Ask students what observations led to the experiments that created the first plastics. You can include this for each experiment the students do, or just write it up on the board as an assumption for all experiments.)

Question: What combination of substances will create a useful material?

Hypothesis: (Choose substances and amounts and predict what will happen when they are combined)

Experiment: (Carefully record the steps of your process. How are you combining your substances? What do you add first?)

Results: (Record the results of your experiment. How stretchy is the material you created? How bouncy? What could it be used for? Name your product and set it aside.)

Have the students modify and repeat the experiment as many times as time allows. If they create a particularly interesting product, see if they can reproduce it two or three times (valid science relies on replicability).

Run this experiment for 10 to 15 minutes. Have the students keep a record of each trial run using the scientific method and also keep their resulting substances. This is not a competition, it is a cooperative effort. Students should feel free to share their results with other teams during the experimental phase. After the time is up, have each team appoint a representative to describe their work and demonstrate their most successful result. What could their product be used for?

Ask the students how they could recreate each substance they made (refer to their notes and ensure they used the same method). Discuss why the scientific method is useful in conducting research. Emphasize the necessity of repetition for verification of results.

Assessment (Outcome 1) Ask students to describe the creation of their substances in terms of what we have learned about polymers. (They should be able to discuss the combination of two substances into a new substance with a different structure in very general terms).

Assessment (Outcomes 2): Quiz students on the basic steps of the scientific method

b. Polymer Discussion

Here's a great description of plastic monomers and polymers from Science Buddies, http://www.sciencebuddies.org/science-fair-projects/Classroom_Activity_Teacher_MilkPlastic.shtml

Plastics are a group of materials that can look or feel different, but can all be molded into many shapes. The similarities and differences between different plastic products come down to the molecules they are made of. Plastics are all similar because they are all made up of molecules that are repeated over and over again in a chain, called a polymer. Polymers can be chains of one type of molecule, or chains of different types of molecules linked together in a regular pattern. In a polymer, a single repeat of the pattern of molecules is called a monomer (even if the polymer is made up of only one type of molecule).

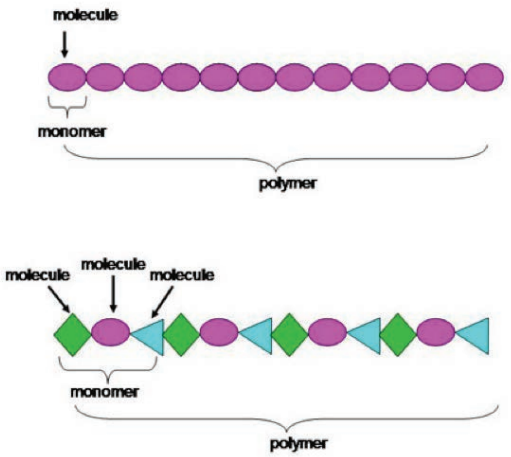

Figure 1. Polymers are made up of repeated patterns of molecules, called monomers. Monomers can be made up of one type of molecule (such as the top polymer) or multiple different molecules (such as the bottom polymer).

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Plastics are created from different chemical combinations.

Plastics are created from different chemical combinations. Different combinations result in different types of plastic being created, and these different types of plastic are used to created different products. Use this chart to find out what type of plastic is used the make the items you use. What can those products be recycled to make?

Household

Plastics

■ In your quest to go green, use this guide to use and sort plastic. The number, usually found with a triangle symbol on a container, indicates the type of resin used to produce the plastic. Call **1-800-CLEANUP** for recycling information in your state.

1 PETE

Number 1 • *PETE or PET (polyethylene terephthalate)*
IS USED IN . . . . . microwavable food trays; salad dressing, soft drink, water, and beer bottles
STATUS . . . . . hard to clean; absorbs bacteria and flavors; avoid reusing
IS RECYCLED TO MAKE . . carpet, furniture, new containers, Polar fleece

2 HDPE

Number 2 • *HDPE (high-density polyethylene)*
IS USED IN . . . . . household cleaner and shampoo bottles, milk jugs, yogurt tubs
STATUS . . . . . transmits no known chemicals into food
IS RECYCLED TO MAKE . . detergent bottles, fencing, floor tiles, pens

3 V

Number 3 • *V or PVC (vinyl)*
IS USED IN . . . . . cooking oil bottles, clear food packaging, mouthwash bottles
STATUS . . . . . is believed to contain phalates that interfere with hormonal development; avoid
IS RECYCLED TO MAKE . . cables, mudflaps, paneling, roadway gutters

4 LDPE

Number 4 • *LDPE (low-density polyethylene)*
IS USED IN . . . . . bread and shopping bags, carpet, clothing, furniture
STATUS . . . . . transmits no known chemicals into food
IS RECYCLED TO MAKE . . envelopes, floor tiles, lumber, trash-can liners

5 PP

Number 5 • *PP (polypropylene)*
IS USED IN . . . . . ketchup bottles, medicine and syrup bottles, drinking straws
STATUS . . . . . transmits no known chemicals into food
IS RECYCLED TO MAKE . . battery cables, brooms, ice scrapers, rakes

6 PS

Number 6 • *PS (polystyrene)*
IS USED IN . . . . . disposable cups and plates, egg cartons, take-out containers
STATUS . . . . . is believed to leach styrene, a possible human carcinogen, into food; avoid
IS RECYCLED TO MAKE . . foam packaging, insulation, light switchplates, rulers

7 OTHER

Number 7 • *Other (miscellaneous)*
IS USED IN . . . . . 3- and 5-gallon water jugs, nylon, some food containers
STATUS . . . . . contains bisphenol A, which has been linked to heart disease and obesity; avoid
IS RECYCLED TO MAKE . . custom-made products

THE OLD FARMER'S ALMANAC

Assessment (Outcome 3) Ask students to describe why different types of plastic have different characteristics

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Most new plastics must be created from raw materials to maintain the products in our current supply stream.

IV. Conclusion and Review (5 min.)

During this lesson we learned about man made polymers and the race to create various types of plastic in the early 20th century. We used the scientific method to experiment with substances we were familiar with in order to create a different products. We also studied how using different types of chemicals can create different types of plastic.

Assessment (Outcome 2) Ask students to think of something they have noticed about the natural world that interested them. Have them create a theoretical experiment to test an observation in terms of the scientific method.

Assessment (Outcome 1) Based on their new knowledge of polymers, ask students why spider silk is so strong for its size

Assessment (Outcome 3) Ask students which type of resin, by number, is used to create most plastic drinking bottles. (This may take further review of the plastic by numbers chart)

V. Follow-up Activities

a. Research the Origin of Plastics

This project could be done either before or after this lesson. Have students write a report on why plastics were created, what the most popular items were originally, and which species the creation of plastic impacted during the first few years they were created (this may be focused on animals saved by production of a manmade material).

b. Track the Changes in Your Created Products

Have students predict how each of their created products will change over the course of a week. Use the scientific method with the given question, "How will my creation change in one week?" Have students create a hypothesis, describe the experiment, and record their results. Compare group results and predict why they are the same or different.

c. Plastics by the Numbers Sorting Activity

Project or print out a plastics by the numbers chart, the one used earlier in this lesson will work or you can find your own. Sort the plastics that have been collected for this curriculum into their number groups. Provide examples of the other types of plastic that aren't available in the class set of materials. Record what the types of plastic have in common and their differences. Note the fact that they generally can't be recycled into what they started out as. This is because the polymers are not able to maintain their original integrity once they go through the recycling process. This means that most new plastics must also be created from raw materials to maintain the products in our current supply stream.

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The United Nations World Ocean Assessment is one of the most comprehensive studies done on the current state of global oceans.

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VI. Additional Resources

a. Sources

- **About.com**
  http://chemistry.about.com/od/demonstrationsexperiments/ss/bounceball.htm
- **Algalita**
  http://algalita.org/credible-information-and-statistics
- **Merriam-Webster**
  http://merriam-webster.com/dictionary/polymer
- **NOAA**
  http://games.noaa.gov/oscar/media/beach_guide.pdf
  http://marinedebris.noaa.gov/sites/default/files/Gen_Plastic-hi_9-20-11_1.pdf
- **The Old Farmer's Almanac**
  http://almanac.com/content/plastics-recycling-chart
- **Plastic: A toxic love story**
  Freinkel, S. (2011). Plastic: A toxic love story. Boston: Houghton Mifflin Harcourt.
- **Science Buddies:**
  http://sciencebuddies.org/science-fair-projects/Classroom_Activity_Teacher_MilkPlastic.shtml
- **United Nations World Ocean Assessment Website:**
  http://www.worldoceanassessment.org/
- **University of California**
  http://idea.ucr.edu/documents/flash/scientific_method/story.htm

b. Vocabulary

In this lesson, these are words that may be unfamiliar to students. In this context, they have the following definitions:

Molecule: "The smallest particle of a substance that retains all the properties of the substance and is composed of one or more atoms." Merriam-Webster.

Monomer: The base units that can create the chains which form polymers.

Polymer: A substance created from multiple repeating chains of monomers.

Scientific Method: "Principles and procedures for the systematic pursuit of knowledge involving the recognition and formulation of a problem, the collection of data through observation and experiment, and the formulation and testing of hypotheses." Merriam-Webster.

Resin: "Any of a large class of synthetic products that have some of the physical properties of natural resins but are different chemically and are used chiefly in plastics." Merriam Webster. Examples of plastic resins are PET, PVC, and Polystyrene.

Hydrocarbon: "An organic compound (as acetylene or butane) containing only carbon and hydrogen and often occurring in petroleum, natural gas, coal, and bitumens." Merriam-Webster.

2016 Marine Debris Fact:

Every ocean and every marine environment contain pieces of our trash.

Washed Ashore Mission Statement:

Washed Ashore builds and exhibits aesthetically powerful art to educate a global audience about plastic pollution in oceans and waterways and spark positive changes in consumer habits.

We Fulfill Our Mission:

Our travelling exhibit of sculptures made completely of marine debris moves around the country in order to reach as many people as possible. Through both educational programs and interactions with our art and signage, we help audiences understand the problems of plastic pollution and marine debris. We offer educational programming at exhibit sites and support materials to educators interested in spreading awareness about plastic pollution through community art.

In order to create the sculptures we build, we first collect trash that has been removed from beaches through community beach cleanups and individual volunteers. This trash is then washed, sorted and prepared for the creation process. Each sculpture is designed and directed by a lead artist and then created through a collaboration of Washed Ashore team members, volunteers, students and artists.

Washed Ashore Facts as of 2016:

- Over 65 giant sculptures have been created.
- Over 35,000 pounds of marine debris have been processed.
- Over 12,500 volunteers have contributed to this project.

Marine Debris Facts as of 2016:

- Every ocean and every marine environment contain pieces of our trash.
- 80% of marine debris comes from land; from streets to streams to rivers to oceans.
- Plastic pollution is becoming one of the most common items in the sea and has entered the bottom of the ocean food chain.

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National Standards Addressed:

Next Generation Science Standards

5-PS1-1.
Develop a model to describe that matter is made of particles too small to be seen. [Clarification Statement: Examples of evidence supporting a model could include adding air to expand a basketball, compressing air in a syringe, dissolving sugar in water, and evaporating salt water.] [Assessment Boundary: Assessment does not include the atomic-scale mechanism of evaporation and condensation or defining the unseen particles.]

5-LS2-1.
Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment. [Clarification Statement: Emphasis is on the idea that matter that is not food (air, water, decomposed materials in soil) is changed by plants into matter that is food. Examples of systems could include organisms, ecosystems, and the Earth.] [Assessment Boundary: Assessment does not include molecular explanations.]

MS-ESS3-3.
Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.* [Clarification Statement: Examples of the design process include examining human environmental impacts, assessing the kinds of solutions that are feasible, and designing and evaluating solutions that could reduce that impact. Examples of human impacts can include water usage (such as the withdrawal of water from streams and aquifers or the construction of dams and levees), land usage (such as urban development, agriculture, or the removal of wetlands), and pollution (such as of the air, water, or land).]

MS-PS1-3.
Gather and make sense of information to describe that synthetic materials come from natural resources and impact society. [Clarification Statement: Emphasis is on natural resources that undergo a chemical process to form the synthetic material. Examples of new materials could include new medicine, foods, and alternative fuels.] [Assessment Boundary: Assessment is limited to qualitative information.]

MS-ESS3-4.
Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems. [Clarification Statement: Examples of evidence include grade-appropriate databases on human populations and the rates of consumption of food and natural resources (such as freshwater, mineral, and energy). Examples of impacts can include changes to the appearance, composition, and structure of Earth's systems as well as the rates at which they change. The consequences of increases in human populations and consumption of natural resources are described by science, but science does not make the decisions for the actions society takes.]

National Curriculum Standards for Social Studies

- **Thematic Standard #2)** Time, Continuity, and Change: Include experiences that provide for the study of the past and its legacy.
- **Thematic Standard #3)** People, Places and Environments: Include experiences that provide for the study of people places and environments.
- **Thematic Standard #7)** Production, Distribution, and Consumption: Include experiences that provide for the study of how people organize for the production, distribution and consumption of goods and services.
- **Thematic Standard #8)** Science, Technology, and Society: Include experiences that provide for the study of relationships among science, technology, and society.
- **Thematic Standard #10)** Civic Ideals and Practices: Include experiences that provide for the study of the ideals, principles and practices of citizenship in a Democratic Republic.