POLYMERS

Teacher Notes

FOURTH GRADE BACKGROUND

- The fourth grades have no experience with polymers
- They know about plastics (a type of polymer) in that they are chemicals and they are indeed all around!
- They know as much about molecules as we've told them in our visits

PREVIOUS LESSON REVIEW

- What did you learn last month magnetism? Can you remember all of the kits that we've done? (Classification, Mass Olympics, Length Measurement, Volume, Density, Electricity, Magnetism)
- What was your favorite experiment?

INTRODUCTION

Polymers are all around us. They can occur as natural products (cotton, wool, hair, DNA) or are manufactured (polyethylene, nylon, plexiglass, styrofoam). There are thousands of polymers used in everyday products. For example, a sandwich bag, plastic water bottle and cap, and sock are all made out of polymers; however, they differ because of the way in which the molecules are joined. The sandwich bag is made up of branched polymer chains, the water bottle is composed of densely packed linear polymer chains, and the cap is composed of cross-linked polymer chains. Cross-linking polymer chains together makes the polymer become more rigid, strong, and less dissolvable. Polymers can be made up of different monomers, or base units. For example, cellulose and Teflon are both polymers; however, they consist of very different monomers.

Some of the properties of polymers that scientists measure are their stretch-ability or elasticity, strength, and melting point. Scientists can create polymers with certain properties by controlling the type of monomers they use to make their polymer and by controlling the amount of cross-linking. Adding pigments, like in crayons, can change the color of polymers. Plastics are a type of polymer and have a wide range of properties. For example, baby diapers have polymers in them that help to soak up water, while a plastic polymer Wegman's bag repels water. Plastics are also recyclable, which allows us to conserve valuable resources: landfill space, energy, and raw materials. The numbers and letter by the triangle on plastic items indicate what type of polymer the plastic is made of. Below is a chart of the recycling codes:

Symbol	1 PETE	2 HDPE	3 V	4 LDPE	5 PP	6 PS
Name	Polyethylene Terephthalate	High Density Polyethylene	Polyvinyl Chloride	Low Density Polyethylene	Polypropylene	Polystyrene
Examples	Peanut butter jar, Pop bottles	Milk jug	Shampoo bottles, Pipes	Bread bag, Shopping bag	Pill bottle, Underwear	Foam cup
Recycled Into	Tote Bag, Hiking shoe, Clothing, Carpet	Doghouse, Park bench, Picnic table, Fence, Pens	Playground equipment, Bubble wrap	Trash can, Trash bag	Brushes and brooms, ice scrapers	Insulated jacket, Concrete, Egg Cartons

DISCUSSION THOUGHTS

Can you name some polymers? Are they natural or synthetic?

VOCABULARY

- **Monomer**: Any small molecule that can undergo a reaction in which it is incorporated into a large molecule containing many similar units
- **Polymer**: A large molecule composed of many smaller monomers covalently bonded together
- **Polymerization**: The chemical process of forming polymers from their component monomers
- **Cross-linking**: The linking of the chains of a polymer to one another so that the polymer becomes stronger and more resistant to being dissolved

ACTIVITIES

- **Polymers DO Exist**
  - Give each student a small square of newspaper. Have them tear it one way and then the other. They will find that it tears straight in one direction and crooked in the other. Explain that newspaper is made from cellulose, a long-chain polymer of β-glucose monomers. When you tear one way, you are tearing between chains (parallel to chains), and you get a clean tear. Tearing the other way doesn't give a straight tear because you're tearing across the chains.
  - Objective: Tearing the newspaper is one way to show that polymers exist in nature.
  - Materials:
    - Newspaper

- **Polymer Kids**
  - Ask the molecules (students) to lock arms and form a chain. Tell students: When we join the monomers, we have created a polymer. Ask, "Since "mono" means one, what do you think "poly" must mean?" Joining monomers to form polymers is a chemical reaction (called polymerization) because a new substance is created. Break the human polymer chain into two smaller chains of four students each. Ask them if it is easier to move as an individual or as a chain. Have the groups stand facing each other. Ask for two more volunteers. Have each new volunteer stand between the two chains and grasp the upper arm of a molecule (student) from each of the two different chains. These new students are the cross-linkers that join the two chains. Ask the entire group to walk across the room. Ask if the cross-linking made movement more difficult. (Groups should conclude that it is more difficult to move with the cross-linkers.)
  - Objective: Illustrate that monomers make polymers and show the effect of adding a cross-linker
  - Materials: None

- **Goop to Go**
  - See Goop to Go Worksheet. Make two silly putties: 1) borax + 50/50 glue and 2) starch + glue
  - Objective: Explore the effects of cross-linking by making real polymers
  - Materials:
    - Plastic sandwich bags
    - Small cups
    - Borax solution (saturated) and Starch solution (in Laundry bottle)
    - Diluted Elmer's Glue Solution
    - Stirring Sticks

- **What Kind of Slime?**
  - Make a chart on the board to compare properties of solids and liquids. Have students brainstorm about properties of each, writing the responses under the appropriate headings. Now ask the students to take baby steps around a spot on the floor in a side-to-side or forward and backward manner. Explain that this is a model of the molecules in a solid. Molecules in solids are constantly vibrating. Instruct students to vibrate while they move around a small section of the room. Note that molecules in a liquid move more freely than molecules in a solid. Tell the students to vibrate and move freely throughout the room to represent gas molecules.
    - SOLID: maintains its own shape, can break into pieces, molecules are densely packed and move slowly
    - LIQUID: takes the shape of the container, can not be broken into pieces, molecules are close enough to maintain shape but have more freedom to move
    - GAS: fills the container, molecules have the greatest amount of movement (free to move anywhere in the container)
  - Objective: To reinforce the difference between solids, liquids, and gases.
  - Materials: None

CONCLUDING THOUGHT

Is the slime we created a solid or a liquid?