GRADE LEVEL: 5-8 | TIME REQUIREMENT: 3 HOURS

CHEMISTRY: PROPERTIES OF MATERIALS

1 READING | 2 ACTIVITIES

INTRODUCTION

World War II came at a time when most manufacturing used natural materials. Clothes were mostly cotton and wool, with some linen and silk. Tires were made of rubber from the sap of a tropical plant, and shoes were made of leather, wood, and that very same kind of rubber. The makeup of the furniture in a house or classroom from World War II and even the clothes that students would have worn is radically different from those today.

One of the key things for students to learn in elementary and middle school science is that materials can be identified by their physical and chemical properties. Engineers, manufacturers, and inventors design materials to have specific properties. Leading up to World War II, this design was done by creating different metallic alloys and by choosing plant and animal products to make fibers. Shortages caused by the outbreak of the war and the diminished access to materials were the impetus for scientists to create new materials. The world of today, dominated by materials made from petroleum products, is a result of the revolution in materials science that started in World War II.

OBJECTIVE

Starting with a reading that asks students to consider the makeup of the built world they live in and to compare it to the past, these resources introduce students to the field of Materials Science. One activity is an experience with an unusual material, that also gives students experience with electricity and circuits. You could supplement this, if you want, with students making and/or testing the properties of other unusual materials, like slime, or oobleck, or bubble solutions. The second activity has students exploring how WWII-era advertisements promoted new technologies and manufacturing, and comparing them to the way science and technology are communicated today.

STANDARDS

NGSS DCI PS1.A
Structure and Properties of Matter

NGSS DCI PS3.A
Definitions of Energy

NGSS DCI ETS2.A
Interdependence of Science, Engineering, and Technology

NGSS DCI ETS2.B
Influence of Engineering, Technology, and Science on Society and the Natural World

NGSS SEP
Developing and Using Models

NGSS SEP
Obtaining, Evaluating, and Communicating Information

NGSS CCC
Patterns

NGSS CCC
Energy and Matter

PERFORMANCE EXPECTATIONS

3-5-ETS1-3
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.

5-PS1-1
Develop a model to describe that matter is made of particles too small to be seen.

5-PS1-3
Make observations and measurements to identify materials based on their properties.

MS-PS1-3
Gather and make sense of information to describe that synthetic materials that come from natural resources and impact society.

READING (1)

1. THE MOTHER OF INVENTION

Description
This short reading introduces the idea of material properties and gets students to think of how things are made and modified to match the needs of a community, population, or country. The reading will set up the activities in this unit. You can try grouping students in pairs or fours to read together or in turns, and to answer the questions.

ACTIVITIES (2)

1. SOFT CIRCUITS

Description
This is an activity that explores the properties of materials, conductivity, and complex circuits. Working in groups, students will be able to answer questions about these concepts through experiments making complex circuits. The worksheet that is included with this activity asks students to draw one of their circuits to demonstrate how electricity flows. Additional activities can consist of having students create parallel and series circuits, and then drawing both circuits on their worksheet.

Supplies (per group)
A tennis-ball sized lump of dough (see recipe below)
2 9V batteries with snap wires
A handful of small LED lights of 3-5V

To make the dough:
Recipe is enough for one class — dough will stay fresh for at least one month when wrapped in plastic.

Ingredients:
- 4 Cups water
- 6 Cups white flour
- 1 Cup table salt
- 3/4 Cup cream of tartar
- 4 Tbsp vegetable oil
- Food coloring

Combine five cups of flour and all other ingredients in a pot. Place the pot on the stove over medium heat and stir continuously. The mixture will begin to boil and start thickening. With the heat still on, keep stirring until the mixture forms a single ball. Remove the mixture from the heat, and place the ball of dough on a lightly floured surface and allow it to cool. Once cool, knead the remaining flour into the dough until it reaches a nice consistency.

The high concentration of salt is what makes the dough conductive. The cream of tartar makes the dough smooth and not so sticky.

Instructions
Demonstrate where everyone can see, under a document camera or at the front of the room, how to construct a simple circuit with the dough. Make two small balls of dough that are close together but not touching. Insert one battery wire in each ball, and then connect one of the lights across the balls. Explain that students might have to rotate the wires across the balls (LED bulbs are polar) before the LED lights up. Students are likely to be very surprised when they see the light go on. Next, show them what happens when the two lumps touch—that the light short circuits and goes out. Go around the room, making sure everyone understands, and ask questions to encourage further exploration. Exploration can include setting up multiple batteries and lights in different types of circuits.

2. ANTIQUE ADS

Description
An activity that uses a modified version of Claim Evidence Reasoning to discuss the relationship between technology, engineering, and society. This activity is a thinking scaffold that has students make a claim, provide evidence to support their claim, and then connect the two with reasoning. Students will work in small groups to analyze WWII advertisements and share and compare their findings with those of the rest of the class.

Supplies
Copies of the handout and reproductions (available from Real World Science site) for each student.

Instructions
Lead students in discussions by having students compare WWII advertisements from *Time* or *Newsweek* to modern technology and other ads they have seen. Use the modified Claim Evidence Reasoning framework to structure their thinking.

READING

MOTHER OF INVENTION

Many things have to come together to make an invention. The timing has to be right, and the inventor has to have a vision of how the creation will fill an important need. One of the major areas of innovation in World War II was in developing new kinds of materials.

PLASTICS IN THE PAST

Today when we say plastic, what we mean is a synthetic polymer, but really all plastic means is a material that is easy to shape. A polymer is a chemical that is made of a repeated chain of smaller chemicals or molecules.

Humans have been using polymers (wood, paper, horn, cotton, linen) for millennia. Rubber and other polymers from plant sap were used for many purposes for centuries until in the 1840s engineers learned to strengthen rubber by treating it with sulfur.

The first synthetic polymers were made in 1860 when John Wesley Hyatt treated cotton fiber with camphor to create celluloid. Celluloid, which could be carved or shaped and then polished, was meant to replace expensive and rare substances like horn, tortoiseshell, and ivory. Although celluloid was important in some manufacturing, in most areas natural polymers were still cheap and plentiful enough to be used instead of human-made ones.

In the early 1900s, chemical engineers began working with a new substance called coal tar.

Coal tar is a by-product of coal production, and engineers learned to make many products from it including dyes and sulfa drugs that were used to fight infections in the human body before penicillin.

A soldier inventories the pharmaceuticals in the hospital at a training camp. *(Image: The National WWII Museum, 2011.065.1960.)*

Medical technicians in a laboratory at Cape Gloucester, New Britain, August 1944. *(Image: The National WWII Museum, 2008.354.216.)*

In 1907, Leo Baekeland made the first completely synthetic plastic. He made it from coal tar and called it Bakelite. Throughout the decades before World War II, more and more plastics were made from coal tar and oil. Although radios, telephones, fancy furniture, jewelry, and sculptures were made from synthetic polymers, most manufactured products still used natural materials.

That all changed with the beginning of World War II.

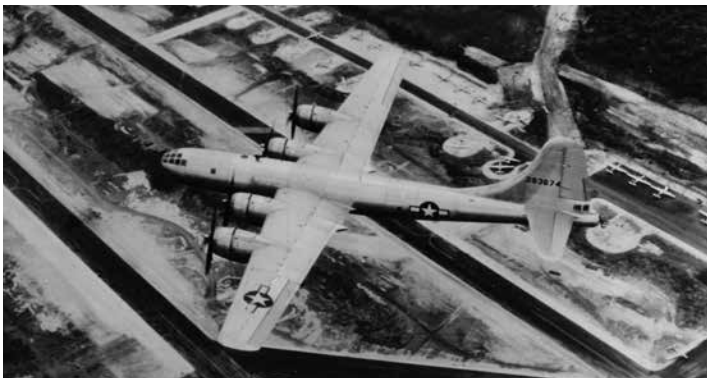
Suddenly electronics systems were needed for tens of thousands of aircraft, boats, ships, radios, and radar systems. All of this equipment needed plastic insulation around their wires. The United States needed rubber for Jeep and airplane tires, tank treads, and soldiers' boots; however the plants that supplied the natural rubber were primarily grown on islands now controlled by the Japanese. Silk, also grown in Asia, was used for both parachutes and pantyhose. Women turned in their pantyhose to make more parachutes, but it wasn't enough, and at the same time plant polymers commonly produced in the tropics were harder to get.

By 1935, a polymer named nylon had been discovered, but it was more expensive than the silk and linen it was meant to replace. During wartime those natural materials were in short supply, and so nylon was used to make parachutes, ropes, and parts of clothing. The balance between the cost of synthetic and natural polymers had changed—manufacturers began developing ways to make products out of polymers from oil to replace plant materials. During World War II, plastic production in the United States increased 300 percent.

NAME: **DATE:**

PLASTICS TODAY

Look around the room you are in. What are all the objects in the room made of? What are your clothes, your backpack, your shoes made of? Chances are most of the objects are made of polymers, and many are synthetic. Synthetic means that it is made from polymers engineers created from oil or another source.



A B-29, the only WWII aircraft with a pressurized cabin, flying over Guam. *(Image: The National WWII Museum, 2010.216.358.)*

1. Fill in the data table below. What are objects in the classroom made of? Are they natural or synthetic?

OBJECT	MADE OF	SYNTHETIC OR NATURAL

2. Are the materials mostly natural or synthetic?

3. What is one object on the list that is synthetic and that you think would have been made of natural materials during World War II? Explain.