The Home Front
A Real World Science Lesson Plan

BACKGROUND:
The US put about 16 million troops into uniform in WWII. Another 115 million or so worked on the Home Front. Every citizen in some way supported the war effort. Dealing with shortages of food and other goods at home, missing family members on the Battle Front, moving into new jobs, roles, and responsibilities, the folks on the Home Front worked hard to support our national effort.

While the Axis powers had been preparing for years for this war, and Great Britain and France had been involved for a while, the US had actively avoided engagement in WWII for quite a span of time.

While some preparations in the military and industry were made in 1940 and early 1941, when war came for the US on Dec 7 1941, the nation was far from ready. Existing factories were modified to make war goods and many new factories were built. New people were brought into the work force, and new methods of production and distribution were developed.

In 1941 the US was not the foremost international power in diplomacy, economics, or military power. By the end of the war in 1945 the US was the dominant force in all these areas.

The great economic expansion that followed for the US in the next decades can be traced to the development of the workforce, and the new methods of development and distribution that took place in WWII. Alongside the technical innovations of the WWII period, these set the stage for the rest of the century.

WWII may have been the original 'Maker Movement.' People had to learn to make do or make their own when supplies and money made resources limited. Families grew their own food, canned it, and came up with new recipes. Manufacturers made up procedures, made airplane engines work in landing craft and tanks, used car engines in airplanes, and were otherwise creative in solving problems. Your ability to be a great maker depends on creativity, teamwork, and persistence, but it helps to know a lot about the physical and chemical properties of materials.

OBJECTIVES:
- Students will be able to describe systems engineering, and how it fits in to the other STEM fields.
- Students will be able to explain how an assembly line works.
- Students will be able to describe the iterative process of design and engineering practice.
- Students will learn about physical properties, and will review phase changes
- Students will learn about chemical properties, and the characteristics of chemical changes

GRADE LEVEL:

5-8 with enrichment activities for advanced students

STANDARDS:

3rd-5th grades:

- Ask questions about what would happen if a variable is changed.
- Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost.
- NGSS Science and Engineering Practices: Asking Questions and Defining Problems
- Because matter exists as particles that are too small to see, matter is always conserved even if it seems to disappear. Measurements of a variety of observable properties can be used to identify particular materials. **3-5 PS1-A**
- Chemical reactions that occur when substances are mixed can be identified by the emergence of substances with different properties; the total mass remains the same. **3-5 PS1-B**

6th-8th grades:

- Ask questions to determine relationships between independent and dependent variables and relationships in models.
- Define a design problem that can be solved through the development of an object, tool, process or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions.
- NGSS Science and Engineering Practices: Asking Questions and Defining Problems
- The fact that matter is composed of atoms and molecules can be used to explain the properties of substances, diversity of materials, states of matter, phase changes, and conservation of matter. **6-8 PS1-A**
- Reacting substances rearrange to form different molecules, but the number of atoms is conserved. Some reactions release energy and others absorb energy. **6-8 PS1-A**

TIME REQUIREMENT:

Assembly Line will take about one hour.
Kitchen Science has two parts—making lip balm will take about one hour. Mixing up the materials for Ginger Ale will take about half an hour, but it will not be ready to sample for 12-24 hours.

MATERIALS:

Student Handouts: Assembly Line, Kitchen Science

For each group you will need:

- 6 retractable ball point pens that can be taken apart
- 6 paper or plastic plates
- Stopwatch

For **Kitchen Science-Lip Balm**, you will need hotplates, disposable plastic pipettes, and containers for mixing and holding the final products. In addition you will need for each group:

- 3 tsp beeswax pellets
- 5 tsp sunflower oil
- 6 drops essential oil

- 1 tsp honey
- Thermometer

For **Kitchen Science-Lip Balm**, you will need for each group:
- 1 tbsp sugar
- 1/4 tsp yeast
- 1 tsp grated fresh ginger
- 2 tsp lemon juice
- 16 oz bottle of water
- You will also need pitchers for the students to empty their bottles of water. They will use that water to make the ginger ale after they add the other stuff to their bottle.

PRIOR KNOWLEDGE:
You may use this as introduction or review for chemical and physical properties. Exactly how you conduct it will depend upon which way you choose.

INFORMATION FOR TEACHERS:
You might give students examples of other assembly lines. Sometimes they have trouble understanding that to be an assembly line they need each person to do a defined and specific task that is different from what the others are doing.

To simplify making lip balm you might just make larger batches and have kids remove theirs and add essential oil directly into it. We often use small mason jars to mix and melt, and buy small vials or plastic containers for students to mix theirs and take home.

For ginger ale, be sure to always use plastic bottles. The pressure from the carbon dioxide made by the yeast will fill up the bottle. When if feels firm it is ready to sample. Glass jars will make it impossible to see how ready it is, and could be dangerous if they go too long.

OUTLINE OF ACTIVITIES:
1. Give students a summary of Systems Engineering, Assembly Lines, Reverse Engineering, and the Design Process. This is one of the rare times you will want to give explanation before activity.
2. Review the parts of the pen and any necessary details of how to take them apart and put them back together. Conduct the **Assembly Line** activity.
3. The two activities in **Kitchen Science** could be conducted independently, and neither needs to be done with **Assembly Line**.

ASSESSMENT:
Student responses on **Assembly Line** will help you see where students are in their understanding of the design process. This is not something they get by doing once, so you will want to continue to providing them opportunities to design solutions.

You could use the activities in **Kitchen Science** as practical assessments of physical and chemical properties.

EXTENSION/ENRICHMENT:

You could also give other assembly activities. For example, a paper airplane assembly line. You could have them design processes for more efficiently getting things done at school and in class, like passing out papers and lining up in the cafeteria.

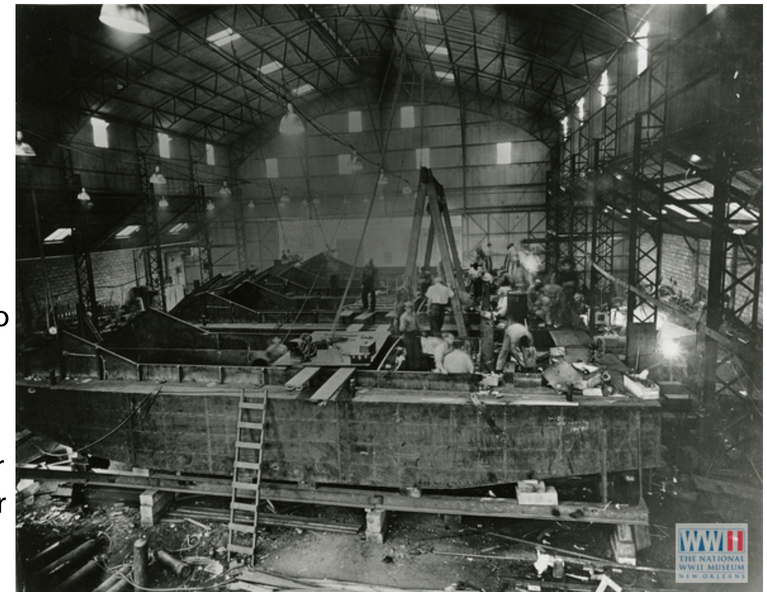
Emphasize the theme of making substances or processes that have the characteristics we want.

REFERENCES:

Freedom's Forge. Arthur Herman, Random House, 2012.

STUDENT HANDOUT

Assembly Lines



Men working on building landing craft at Higgins Industries during the war. The National WWII Museum, 2008.280.010.

At home do you put all your clothes in one drawer all mixed up, or do you have a drawer for socks, and a drawer for shirts, and places for every kind of thing?

For school do you just shove everything loose in your backpack, or do you have a notebook with dividers and sections for every class? Do you have different folders for different classes?

Does your school have buses that roam the neighborhood looking for kids who need to come to school, or do they have set bus routes, and kids go to stops on the route to get their ride to school. Or maybe there are carpools, and some drop-off procedure?

These are all questions about Systems Engineering. A Systems Engineer designs processes and procedures and systems to get things done efficiently. If you keep your clothes organized in different drawers, you are a systems engineer. The person at your school who sets up buses and drop-off might be called an Operations Manager—Operations Research is another name for Systems Engineering.

One way that engineers design great things is by taking already made things apart, to see how they work, and to figure out improvements. This is called Reverse Engineering. For example, in WWII the US captured some Japanese airplanes, and took them apart to see how they worked. This gave us information on the strengths and weaknesses of the Japanese planes, and the best ways to defeat them.

An important strategy for putting things together efficiently is to use an Assembly Line. In an Assembly Line different parts of a process are completed by different people in different places. For example, cars are usually built on an Assembly Line. This is easier for a bunch of reasons—one is that you don't have to have every part everywhere. You can deliver tires and the tools to put them on in just the place where they are put on, and windshields only in their one place. It also means that if something goes wrong, like the carburetor doesn't work, that you know where it went wrong and how to fix it. Every car should come out the same because the same person put together the same parts in the same order for every car.

STUDENT HANDOUT

Assembly Lines

In this activity, you will put design an Assembly Line to manufacture pens ball point pens. Your team will design and test processes to put the pens together. You will modify your design and practice your process to get faster and more efficient.

At the end there will be a competition. The team that can assemble 6 pens that work in the shortest amount of time will win the contract for pen assembly!

Describe your first assembly line attempt (include a diagram):

Describe your final assembly line attempt (include a diagram):

STUDENT HANDOUT

Assembly Lines

Trial	Variable changed	Time	Change in time	Notes/Observations
Trial 1				
Trial 2				
Trial 3				
Trial 4				
Trial 5				
Trial 6				
Trial 7				
Trial 8				
Trial 9				
Trial 10				
Trial 11				
Trial 12				

STUDENT HANDOUT

Kitchen Science

Servicemen cooking in a mess hall kitchen at training camp in California on 25 February 1944. The National WWII Museum, 2011.065.723.

During WWII there were many shortages of common household items. People got used to making their own things and making do with what was on hand during The Great Depression, and they continued doing it through the war. To make substances have the characteristics you want, you need to know about the properties of their ingredients. Sometimes what we make involves physical properties and physical changes, and sometimes it involves chemical properties and chemical changes.
Follow the instructions to make something cool that you can use. Determine if your making involved chemical or physical changes.

Lip Balm

In a jar or bowl put:

- 3 tsp beeswax pellets
- 5 tsp sunflower oil
- 6 drops essential oil
- 1 tsp honey

Then heat it up on a hot plate. All the substances will melt—stir them together occasionally until they do. Monitor the temperature of the mixture. Record the temperature at which it all becomes liquid. Take it from the hot plate and carefully use a disposable dropper to add it to your jar. It will cool and become solid. Record the temperature at which it starts becoming solid.

Temperature at which all substances are liquid: ____________________

Temperature at which it starts solidifying: ____________________

STUDENT HANDOUT

Kitchen Science

Ginger Ale

You will need:

- 1 tbsp sugar
- 1/4 tsp yeast
- 1 tsp grated fresh ginger
- 2 tsp lemon juice
- 16 oz bottle of water

Empty your water bottle into a pitcher or some other container. Add the other ingredients to your bottle, then refill it with water. Cap tightly and stir vigorously. Leave the jar on the counter or in some other place in your classroom that is out of the sun. Before you leave it, squeeze the bottle to feel how hard it is. After 12-24 hours check it again.

What are the characteristics of chemical change? In other words, how can you tell if a change is a chemical change?

Which of the two things you made involved chemical change, and which involved physical change? What reacted in the chemical change? What kind of physical change occurred? Answer below and make your reasoning clear:

Physical Change:

Chemical Change: