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Standards

Arizona

> **6.L2U1.14:** Construct a model that shows the cycling of matter and flow of energy in ecosystems.

NGSS

> **MS-ESS3-2:** Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.

Materials

> **PowerPoint**
> **Design a Bioproduct Worksheet**
> **Paper**
> **Colored Pencils**
> **Device with an internet connection to conduct online research**

Overview

This lesson introduces students to bioproducts. Students gain an understanding of the role of bioproducts in society.

Grade Level: 6–8

Goals

Students will learn about the concept of bioproducts and how bioproducts can solve problems or needs they have experienced.

Learning Objectives

Students will be able to define bioproducts.

Students will be able to differentiate between nonrenewable and renewable sources.

Students will be able to recognize the connection between agriculture and bioproducts.

Students will be able to give examples of bioproducts.

Students will be able to design a bioproduct to solve a problem or need.

Vocabulary

Agriculture: (noun) growing and harvesting crops and/or raising animals or livestock

Bioeconomy: (noun) the system of making products derived from renewable materials and trading them for a value

Bioproducts: (noun) materials, chemicals and energy derived from renewable biological sources

Biofuels: (noun) fuels produced using biomass instead of fossil fuels (examples are biodiesel and ethanol)

Fossil fuels: (noun) materials that can be used to produce energy (heat or power) that were created from plants and animals that lived millions of years ago

Non-renewable sources: (noun) things that will run out or will not be replenished for a long time

pH: (noun) scale that indicates how acidic or basic a substance is (pH of 7 is neutral, pH <7 is acidic, and pH >7 is basic)

Product design process: (noun) the set of steps used to create a new product; the steps are: define the problem, do research, brainstorm solutions, design the product, build a prototype, test and redesign, and communicate results. These steps can also fit in four main phases: problem definition, design exploration, design optimization, and design communication.

Renewable sources: (noun) things that can grow again quickly or never run out

Set Up

Students will be working in groups of three to four. Each student will need a device and access to the internet to conduct online research. Students should have access to colored pencils and paper to create posters. Posters/presentations can also be created digitally.

Lesson Procedure

Day 1: Introduction to Bioproducts
Teacher materials needed: PowerPoint 1: What are Bioproducts?
Student materials needed: Paper and pencil for notetaking, a device with an internet connection, and colored pencils and paper to create a poster.

1. **Introduction (Slide 2):** Introduce today's objectives. (1 min)
2. **Engagement Activity (Slides 3-6):** This activity involves the whole class and small groups. In step 1, the whole class will come up with a list of plants that grow in the Sonoran Desert both naturally and farmed (for example: cactus, saguaro, corn, pecans, dates, cotton, and palo verde tree). (3 min) In step 2, the students will work in small groups to find what type of products can be made from the plant list of step 1 (for example: biofuels from corn, leather from cactus, and fabric from cotton). (8 min) In step 3, the list of products from step 2 will be compiled as a class. (2 min) In step 4, the class will come up with important products (that are not food) they need every day (for example: cellphones, car, laptops, video games, and clothing). (2 min) In step 5, the students will work in small groups to make a poster depicting one of the important products and how it can be made from other products from plants, as seen in slide 6. (10 min) Groups will share their posters to the class. (5 min)
3. **Presentation/Discussion (Slides 7-14):** Provide students the definition of bioproducts, non-renewable and renewable sources. On slide 8, ask students if bioproducts are made from non-renewable or renewable sources. On slide 11, ask students the two questions on the slides before clicking for the answers to appear. Remind the students that the growing conditions in the Sonoran Desert are generally: water not very abundant, full sun, basic pH (around 7-8.5), and a dry climate. (Note: Different plants have different soil pH ranges where they grow the best. Soil pH depends on the materials in the soil. Desert soils tend to have a basic pH.) (12 min)
4. **Activity (Slides 15):** During this activity, students should work individually and write down their answers to the three questions. The purpose of this activity is for students to reflect on what bioproducts are and their connection to agriculture. This could be used as an assessment or discussion prompt. (7 min)
5. **Closure (No slide):** Answer any questions and discuss connections to future lessons and topics. (2 min)

Day 2: Product Design Process
Teacher materials needed: Powerpoint 1: What are Bioproducts?
Student materials needed: Paper and pencil for notetaking, a device with internet connection, and Design a Bioproduct Worksheet.

1. **Introduction (Slide 16):** Introduce today's objectives. (1 min)

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Lesson Procedure

2. **Engagement Activity (Slide 17):** During this think-pair-share activity, students will discuss and write down their own ideas in response to the question: What is a problem you, your family, your community, or the world has and which you wish to find a solution for? The objective of this activity is for students to start thinking about a problem they have interest in solving. (5 min) Students will share what their group discussed. (2 min)
3. **Presentation/discussion: (Slide 18-21):** Review the definition of bioproducts and discuss examples from these plants: corn, soybeans, and guayule. For slide 19, see content below. Discuss how bioproducts can solve problems. Discuss the steps of the product design process. (7 min)

Examples of corn bioproducts

- Textiles (material) – Like clothing.
- Biopolymers (material) – These are plastic-like materials. Examples are cups, paper coatings, carpeting and 3-D printing ink. A brand example are some Reebok shoes that have the sole (plastic-like material) made from corn and the rest of the shoe made from cotton.
- Xanthan gum (chemical) - Use as thickener and stabilizer (prevents ingredients to separate) for products such as lotions, ice cream, salad dressings, medicines, etc.
- Vitamin C and Vitamin E (chemical)
- Amino acids (chemical) – Use in supplements to help with recovery from exercise.
- Citric and lactic acid (chemical) – These preserve foods and add sour taste to food, for example yogurt.
- Ethanol (energy) - It is a liquid produced by fermentation of sugars by yeast. The sugars inside the plant are broken down by yeast to make carbon dioxide and ethanol. Ethanol is added to gasoline, around 10-15% of gasoline is ethanol.

Examples of soybean bioproducts

- Candles (material)
- Textiles (material) – An example is the making of cloth from the leftover pulp from the process of making tofu, soymilk and other soy products. A brand example is BabySoy which makes baby clothes from soybeans.
- Ink and paints (chemical)
- Adhesives (chemical)
- Cleaning supplies (chemical)
- Shampoo (chemical)
- Hand sanitizer (chemical)
- Biodiesel (energy) - Ethanol is a type of biofuel. Biodiesel is a type of biofuel. Ethanol and biodiesel are not the same thing. Biodiesel is used in diesel engines. Vehicles like trucks, boats, and buses have diesel engines. Small vehicles, like the cars we drive, usually have engines that use a mixture of gasoline and ethanol.

Examples of guayule bioproducts

- Natural rubber (material) - It is stronger, and more heat and tear resistant than synthetic rubber. It is used in vehicle tires. Smaller cars need 10-40% natural rubber in their tires, but larger tires that are needed for more demanding application need a larger percentage of natural rubber, like aircraft tires need almost 100%.
- Organic resins (chemical) - Use in furniture varnishing, food glazing, and glue.
- Biodiesel (energy)

4. **Activity (Slides 22-23):** During this think-pair-share activity, students will solve a problem they are interested in using bioproducts. See example on slide 23. Students will focus on the first half of the products design process to accomplish this. Students will fill out a Design a Bioproduct Worksheet. Students are encouraged to do additional online research to find more examples of bioproducts that can be useful to solve their problem. (20 min) Students will then present to the class. (5 min)

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Lesson Procedure

5. **Activity (Slide 24):** During this activity, students should work individually and write down their answers to the three questions. The purpose of this activity is for students to reflect on what a bioproduct is and what the product design process entails. This could be used as an assessment or discussion prompt. (8 min)
6. **Closure (No slide):** Answer any questions and discuss connections to future lessons and topics. (2 min)

Further Exploration (Resources, links, topics, etc.)

- 7 Steps of the Design Process. Indeed Career Guide. Retrieved 2020, from www.indeed.com/career-advice/career-development/design-process
- Advanced Bioproducts. (n.d.). Retrieved 2020, from https://corn.org/products/advanced-bioproducts/
- Fact Sheets and Newsletters. (2020, July 13). Retrieved 2020, from https://sbar.arizona.edu/resources/publications/fact-sheets-newsletters
- Fossil fuels continue to account for the largest share of U.S. energy. U.S. Energy Information Administration (EIA). (2019) Retrieved 2020, from https://www.eia.gov/todayinenergy/detail.php?id=41353
- The Engineering Design Process. Science Buddies (2020, May 19). Retrieved 2020, from www.sciencebuddies.org/science-fair-projects/engineering-design-process/engineering-design-process-steps
- Sweet Sorghum Biofuel. The University of Arizona: Biosystems Engineering. Retrieved 2020, from https://be.arizona.edu/content/sweet-sorghum-biofuel
- United Soybean Board. (2013, September 16). 2017 Soy Products Guide. Retrieved 2020, from https://reader.mediawiremobile.com/USB/issues/200233/viewer?page=24

Author Biography

Arisbeth Ibarra Nieblas is a third-year doctoral student in Environmental Engineering at the University of Arizona. She majored in Chemical Engineering at the Technological Institute of Sonora (ITSON), Ciudad Obregon, Mexico. Her graduate research involves developing a continuous corrosion monitoring station for water delivery pipe metal. As a third-year SBAR Fellow, Arisbeth continues to create educational content for middle school-aged students, including science experiments and activities that involve complex topics like bioeconomy.

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