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| **Lesson Overview:** Students will explore the exciting world of bioplastics by creating and comparing bioplastics made from milk and soybean oil. Through hands-on experimentation, they'll assess the properties of each bioplastic and analyze the potential of bioplastics as sustainable alternatives. | | | | | | **Essential Question:** Can bioplastics created from readily available resources like milk and soybean oil offer a viable and sustainable alternative to traditional plastic? | | |
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| **Lesson Breakdown (Lessons are based on 45 min classes)**  Lesson 1: Creating Bioplastics  Lesson 2: Comparing the Results  Lesson 3: Engineering Challenge | | | | | | **Subjects**   * Science * Technology * Engineering * Math * ELA * Art * Other (AFNR, EE?) | | |
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| **I CAN**   * explain how bioplastics are made from natural resources like milk and soybean oil. * compare and contrast the properties of bioplastics made from milk and soybean oil with traditional plastics. * analyze the potential of bioplastics as a sustainable alternative to traditional plastics. * design a product using bioplastics, considering its functionality, sustainability, and potential applications. * design and create a product using bioplastics considering its functionality, sustainability, and potential applications. * communicate my findings and ideas about bioplastics * calculate ratios related to the bioplastic creation process and interpret the results. | | | | | **Performance Expectations/ Standards**  **NGSS Standards:**  **MS-PS1-3:** Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.  **MS-ETS1-1:** Define the criteria and constraints of a design problem as it relates to the function and properties of a designed product.  **MS-ETS1-2:** Evaluate competing designs that solve a problem based on a variety of criteria.  **CCSS Standards:**  **W.4.7:** Conduct short research projects that build knowledge about a topic. (Research/Gathering Information)  **W.4.8:** Recall relevant information from experience or gather information from print and digital sources; organize that information, and write clearly and concisely. (Research/Gathering Information)  **6.EE.B.8:** Solve real-world and mathematical problems by applying and extending understanding of ratios and rates. | | | |
| **Teacher Background**  The ever-growing concern surrounding traditional plastic pollution has fueled research into biodegradable alternatives derived from renewable resources. **Bioplastics**, a diverse group of materials derived from biological sources like plants, animals, and microorganisms, are gaining significant attention as potential solutions. Among these, bioplastics derived from readily available resources like milk and soybeans hold promise due to their unique properties and potential for sustainable production.  Milk protein-based bioplastics utilize casein, a milk protein separated through processes like acidification or renneting. Casein exhibits film-forming properties, allowing it to be molded into various shapes after plasticization with natural or synthetic compounds. These bioplastics offer advantages like biodegradability, good mechanical strength, and the potential for food waste valorization. However, challenges remain, including limited water resistance and higher production costs compared to conventional plastics.  Soybean oil-based bioplastics typically involve the use of triglycerides, the main component of soybean oil. These triglycerides can be converted into biopolymers through various processes, including polycondensation and polymerization with renewable monomers. The resulting bioplastics exhibit good flexibility, oil resistance, and potential for industrial-scale production. However, limitations include potential competition with food production and the need for further research to optimize biodegradability and cost-effectiveness.  Despite the challenges, research and development efforts continue to improve the properties and production efficiency of milk and soybean-based bioplastics. Additionally, life cycle assessments are crucial to evaluate their overall environmental impact compared to traditional plastics. As research progresses and production methods are optimized, bioplastics derived from milk and soybeans have the potential to become viable and sustainable alternatives in various applications, contributing to a circular bioeconomy. | | | | | | | | |
| **Essential Vocabulary**   * Biodegradable * Bioplastic * Renewable resource * Sustainable * Polymer | | | **Materials**   * Safety goggles * Measuring spoons/ cups * Oven mitts * A stove top/ hot plate and/ or microwave   **For Milk Bioplastic: (per group)**   * 120 mL Milk * 10 mL White vinegar * Strainer (or use cheese cloth) and bowl to collect the liquid * Spoons * Paper towels   **For Soy Bioplastic: (per group)**   * 15 mL cornstarch * 5 mL soybean (vegetable) oil * 1 sandwich-size resealable plastic bag * 2 drops food coloring (any color) - optional * 15 mL water | | | | | |
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| **Lesson 1: Creating Bioplastics** | | | | | | | | |
| **Time** | | **Materials** | | | **Activity** | | | |
| 15 mins | | [From Farm to Form: Creating and Comparing Bioplastics](https://docs.google.com/presentation/d/1UvzpBC8peyH49wuve7QVJeauNmo-n4WlZGdQXce4FkE/edit?usp=sharing) | | | Briefly review soybeans, their oil, and the concept of bioplastics. discuss the environmental concerns of traditional plastic and introduce the concept of bioplastics.  Introduce the challenge to the students: Today they will be making two different kinds of bioplastic - one out of milk and the other out of soybean oil. | | | |
| 5 mins | | [From Farm to Form: Creating and Comparing Bioplastics from Everyday Resources Student Worksheet](https://docs.google.com/document/d/1sbD0X6waXltOmvUvyJ0P_IDRz5xv2oaMr_fZa8ez1Ks/edit?usp=sharing) | | | Review with the students the procedures they will follow when creating their bioplastics. Stress the importance of wearing goggles at all times and using caution with the stovetop/ hot plate and microwave. | | | |
| 25 mins | | [From Farm to Form: Creating and Comparing Bioplastics from Everyday Resources Student Worksheet](https://docs.google.com/document/d/1sbD0X6waXltOmvUvyJ0P_IDRz5xv2oaMr_fZa8ez1Ks/edit?usp=sharing)     * Safety goggles * Measuring spoons/ cups * Oven mitts * A stove top/ hot plate and/ or microwave   **For Milk Bioplastic: (per group)**   * 120 mL Milk * 10 mL White vinegar * Strainer (or use cheese cloth) and bowl to collect the liquid * Spoons * Paper towels   **For Soy Bioplastic: (per group)**   * 15 mL cornstarch * 5 mL soybean (vegetable) oil * 1 sandwich-size resealable plastic bag * 2 drops food coloring (any color) - optional * 15 mL water | | | Monitor the students as they conduct the experiments, paying careful attention to their use of the hot plate and microwave. | | | |
| OPTIONAL | | [From Farm to Form Student Reading Passage](https://docs.google.com/document/d/19MNweb7ICfmELd4luOHOB50thIIi9lnfM0JR2RmuoAg/edit?usp=sharing) | | | Assign the reading passage to the students for homework  [From Farm to Form Student Reading Passage Answer Key](https://docs.google.com/document/d/1hZ2T6DIAl6XJMTpwEV-UeekrDeTQL7-5G4X1cBgXWPI/edit?usp=sharing) | | | |
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| **Lesson 2: Comparing the Results** | | | | | | | | |
| **Time** | | **Materials** | | | **Activity** | | | |
| 15 minutes | | Bioplastics created previously  Plastic objects  [From Farm to Form: Creating and Comparing Bioplastics from Everyday Resources Student Worksheet](https://docs.google.com/document/d/1sbD0X6waXltOmvUvyJ0P_IDRz5xv2oaMr_fZa8ez1Ks/edit?usp=sharing) | | | (The plastics will take a few hours to dry.)  Once both bioplastics are dry and solidified, observe their appearance, texture, and flexibility. Gently try to bend or tear the bioplastics and compare their strength and brittleness to plastic items in the classroom. | | | |
| 15 mins | | [From Farm to Form: Creating and Comparing Bioplastics from Everyday Resources Student Worksheet](https://docs.google.com/document/d/1sbD0X6waXltOmvUvyJ0P_IDRz5xv2oaMr_fZa8ez1Ks/edit?usp=sharing) | | | Assist the students as they calculate the percent yield of the plastics and answer the analysis questions. | | | |
| 15 mins | | [From Farm to Form: Creating and Comparing Bioplastics from Everyday Resources Student Worksheet](https://docs.google.com/document/d/1sbD0X6waXltOmvUvyJ0P_IDRz5xv2oaMr_fZa8ez1Ks/edit?usp=sharing) | | | Introduce the Engineering Challenge to the students and allow them time to brainstorm and plan to complete the Challenge during the next class. Be sure they identify any materials they might need to bring in from home.  Challenge:  The bioplastics created in the experiment are not as strong, flexible, or water-resistant as desired. Design a way to Improve the properties of the bioplastics and a procedure to test it.  If students are struggling, suggest experimenting with different ratios of ingredients, exploring the use of adding other natural materials, like adding natural fibers for reinforcement, experimenting with different drying methods, or exploring the use of different ratios or combinations of ingredients. | | | |
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| **Lesson 3: Engineering Challenge** | | | | | | | | |
| 35 mins | | [From Farm to Form: Creating and Comparing Bioplastics from Everyday Resources Student Worksheet](https://docs.google.com/document/d/1sbD0X6waXltOmvUvyJ0P_IDRz5xv2oaMr_fZa8ez1Ks/edit?usp=sharing) | | | Remind the students to wear their goggles and to work safely around the stove top/ hot plate and microwave. Monitor the students as they conduct their experiments. | | | |
| 10 mins | | [From Farm to Form: Creating and Comparing Bioplastics from Everyday Resources Student Worksheet](https://docs.google.com/document/d/1sbD0X6waXltOmvUvyJ0P_IDRz5xv2oaMr_fZa8ez1Ks/edit?usp=sharing) | | | Have the students share their projects with the class and discuss what went well and what did not work well. | | | |
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| **Differentiation**  **For students who need additional support:**   * Pre-measure the bioplastic ingredients and focus on the testing and comparison aspect. * Conduct the experiments as a whole class * Allow students to use calculators as needed.   **For students who need additional challenges**:   * Research and present on different types of bioplastics and their ongoing development * Investigate the concept of composting and discuss how bioplastics can be disposed of sustainably. * Design a campaign to raise awareness about the benefits of using bioplastics and reducing plastic waste and how individuals can contribute to a more sustainable future. | | | | | | | | |
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| **Extension**   * Have the students try milks with different amounts of fat to see if there is a difference in yield or characteristics of the bioplastic. * Research the different stages of plastic production and disposal. * Conduct experiments to test the biodegradability of bioplastics under different conditions. * Research the environmental impact of plastic production and disposal. * Explore other sustainable alternatives to plastic, such as reusable bags or biodegradable materials like paper or bamboo. | | | | | | | | |
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| **Assessment**   | **Criteria** | **4 - Exemplary** | **3 - Proficient** | **2 - Developing** | **1 - Beginning** | | --- | --- | --- | --- | --- | | **Following Procedures** | Follows all procedures meticulously, demonstrates safe and responsible lab habits. | Follows procedures mostly, may require minor reminders. | Follows procedures with some guidance, may make minor mistakes. | Does not consistently follow procedures, requires frequent reminders. | | **Data & Observations** | Records detailed and accurate data in a well-organized manner. Observations are clear, specific, and insightful. | Records most data points accurately. Observations are generally clear but may lack detail. | Records some data points, but may be incomplete or inaccurate. Observations are basic and lack detail. | Records minimal or inaccurate data. Observations are unclear or absent. | | **Analysis Questions** | Provides well-developed and thoughtful answers that demonstrate a clear understanding of the concepts. Makes connections between data and observations. | Answers questions adequately, demonstrating a basic understanding of the concepts. | Answers questions partially, with some confusion about the concepts. | Answers lack detail or demonstrate a misunderstanding of the concepts. | | **Biodegradability & Improvement Plan** | Develops a clear and well-defined plan to test biodegradability. Creates a detailed and innovative plan to improve the bioplastics. | Develops a plan to test biodegradability, but it may need some refinement. Creates a plan to improve the bioplastics, but it may lack detail or originality. | Develops a basic plan to test biodegradability. Improvement plan is present but lacks detail or creativity. | Does not develop a plan to test biodegradability or improve the bioplastics. | | **New Experiment** | Conducts the new experiment following the improved plan meticulously. | Conducts the new experiment with some guidance. | Conducts the new experiment with some difficulty. | Does not successfully conduct the new experiment. | | **Presentation** | Presentation is clear, engaging, and effectively communicates findings. | Presentation is informative but may lack some clarity or engagement. | Presentation is basic and may lack detail. | Presentation is unclear or missing. | | | | | | | | | |