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| **Lesson Overview:** Students will explore the science behind genetically modified organisms (GMOs) by comparing the growth of genetically modified and non-GMO soybean seeds. Through experimentation and analysis, they will evaluate potential benefits and drawbacks of GMO technology in agriculture. | | | | | | | **Essential Question:** Do genetically modified soybean seeds exhibit any differences in growth rate or overall plant health compared to non-GMO seeds under controlled conditions? | | | |
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| **Lesson Breakdown**  ***NOTE: students will plant the seeds on Day 1. Germination should be noted between Days 3 and 10 and growth measured for at least 18 days.***  Lesson 1: Planting Soybeans  Lesson 2: Observation  Lesson 3: Analysis  Lesson 4: Engineering Challenge | | | | | | | **Subjects**   * Science * Technology (moisture sensors, optional) * Engineering * Math * ELA * Art * Social Studies * Other\_\_\_\_\_\_ | | | |
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| **I CAN statements**   * can explain the concept of genetically modified organisms (GMOs). * differentiate between GMO and non-GMO seeds. * design and conduct a controlled experiment to compare the growth of GMO and non-GMO soybean seeds. * collect and analyze data on plant growth parameters. * draw conclusions based on my observations and data analysis. * I can communicate my findings and reasoning in a clear and concise way. | | | | | | **Performance Expectations/ Standards**  **NGSS Standards:**  **MS-LS1-5:** Conduct controlled investigations to provide evidence to support explanations for how variations in characteristics affect survival and reproduction of organisms.  **MS-ETS1-1:** Define the criteria and constraints of a design problem as it relates to the function and properties of a designed product.  **CCSS Standards:**  **6.SP.1:** Recognize a statistical question as one that anticipates variability in the data related to the question and acknowledges that it takes multiple observations to get a reliable answer.  **6.SP.2:** Understand that a measure of center (such as mean, median, or mode) summarizes the center of the data and that a measure of spread (such as range or interquartile range) summarizes the spread of the dat**a.**  **6.W.1:** Write arguments focused on a persuasive claim using evidence and reasoning.  **National Council for Social Studies (NCSS) Framework**  **D2.Civics/Government:** Students will be able to explain how scientific or technological advancements can affect public policy decisions (e.g., the regulation of genetically modified organisms).  **D3. Economics:** Students will be able to explain how economic systems influence or are influenced by technological advancements (e.g., the impact of GMOs on agricultural production costs and global food security). | | | | |
| **Teacher Background**  Genetically Modified Organisms, or GMOs, have become a significant topic in agriculture, particularly with regards to soybeans. These modified plants are created by introducing specific genes from other organisms, often bacteria, into the soybean genome. This allows soybeans to develop new traits, such as resistance to herbicides or pests.  The primary benefit of GMO soybeans for farmers is increased yield and reduced costs and inputs. Herbicide-resistant soybeans allow farmers to use specific weed killers without harming the crop itself, simplifying weed management. Additionally, pest-resistant varieties experience less crop loss due to insect damage. This translates to higher overall soybean production, which is crucial for meeting global food demands.  However, the use of GMO soybeans also raises concerns. Some scientists worry about the potential for unintended consequences on the environment, such as the creation of "superweeds" resistant to the herbicides used on GMO crops. Additionally, there are ongoing discussions about the safety of consuming genetically modified foods for human health, although no conclusive evidence of harm exists at this time. The debate surrounding GMO soybeans reflects the complex interplay between scientific advancements, agricultural practices, and potential long-term impacts on our food system**.** | | | | | | | | | | |
| **Essential Vocabulary**   * Genetically Modified Organism (GMO) * Germination Rate * Hypothesis * Non-Germinated Seed * Sprout * Variable | | |  | **Materials**   * [The Great Seed Showdown - presentation](https://docs.google.com/presentation/d/1efTHy6qv23FtQuPRpu4GbxHc3txNINTffJeLqxgoe4U/edit?usp=sharing) * [The Great Seed Showdown- Student Worksheet](https://docs.google.com/document/d/17SVXHE-0HVpVHqbiNmyxIbNQ1_7dvloSzx6pc6RJ_fE/edit?usp=sharing) * Computer access   **Per group**   * Two 8” peat pots with a tray to collect excess water * Potting soil * Water spray bottle * Labels for each pot (GMO, Non-GMO) * 5 GMO soybean seeds * 5 Non-GMO soybean seeds * Rulers * Optional: grow lights (if planting indoors) * Optional: Moisture sensors | | | | | | |
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| **Lesson 1: Planting Soybeans** | | | | | | | | | | |
| **Time** | | **Materials** | | | | **Activity** | | | | |
| *Prior to class, divide the seeds up into containers for the students. Mark the GMO seed #1 and the non-GMO seeds #2 so you will be able to easily identify them but the students won’t.* | | | | | | | | | | |
| 15 mins | | [The Great Seed Showdown - presentation](https://docs.google.com/presentation/d/1efTHy6qv23FtQuPRpu4GbxHc3txNINTffJeLqxgoe4U/edit?usp=sharing) | | | | Show the first slide. Ask the students to identify what all of these things have in common.  Are they surprised that they are all things that start with soybeans?  Continue with the presentation- it directs you to stop at Slide 8 to ask the students what they think influences how a plant grows. And on Slide 9 the students make suggestions about the ways we can affect plant growth. | | | | |
| 5 mins | | GMO and non-GMO seeds | | | | Show the students the different seeds and ask them to see if they can tell which is the GMO seed and which is the Non-GMO seed(they will not be able to tell the difference)  Ask them how we might be able to tell the difference. | | | | |
| 10 mins | | [The Great Seed Showdown- Student Worksheet](https://docs.google.com/document/d/17SVXHE-0HVpVHqbiNmyxIbNQ1_7dvloSzx6pc6RJ_fE/edit?usp=sharing) | | | | Explain the experiment objective: to compare the growth of GMO and non-GMO soybean seeds under controlled conditions.  Forming a Hypothesis: Guide students to develop a hypothesis about which type of seed (GMO or non-GMO) they expect to show a faster growth rate or better overall health.  Have the students complete their hypotheses and identify the experiment’s variables in their workbook | | | | |
| 15 mins | | * Two potting trays or containers with drainage holes * Potting soil * Water spray bottle * Labels for each pot (GMO, Non-GMO) * 5 GMO soybean seeds * 15 Non-GMO soybean seeds * Optional: grow lights (if planting indoors) * Optional: moisture sensors | | | | Have the students label their containers with the seed number and their group names.   1. **Preparation:** Divide potting soil evenly between the two containers. Moisten the soil lightly with a spray bottle. 2. **Planting:** Plant 5 of the #!! seeds in one pot and 5 of the #2 seeds in the other pot, spacing them evenly with some distance between them. 3. **Watering:** Gently water the soil again to settle the seeds. 4. **Placement:** Place the pots in a sunny location indoors (or under grow lights) at room temperature | | | | |
| OPTIONAL | | [GMO and Soybeans Student Reading Passage](https://docs.google.com/document/d/1AShdOU7PlDv-rtLbz1FTZ5aBrnpKXwq30hoFcwbKcCI/edit?usp=sharing) | | | | Assign the reading passage and questions as homework.  [GMO and Soybeans Student Reading Passage Answer Key](https://docs.google.com/document/d/1qsgpm5zu6y0VT7YaLichtjvkV7BazwcHaMxJXc2ElUk/edit?usp=sharing) | | | | |
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| **Lesson 2: Observation**  *Note: Lesson 4 can be completed while the students are observing the growth of their plants.* | | | | | | | | | | |
| **Time** | | **Materials** | | | | **Activity** | | | | |
| **Germination and Growth** | | | | | | | | | | |
|  | | [The Great Seed Showdown- Student Worksheet](https://docs.google.com/document/d/17SVXHE-0HVpVHqbiNmyxIbNQ1_7dvloSzx6pc6RJ_fE/edit?usp=sharing) | | | | **Observation**: Have the students observe the pots daily, keeping the soil moist but not soggy. They will record this in their data chart in the Student Workbook.  **Germination Rate:**  Students will count the number of seeds that germinate (sprout) in each pot within 10 days and then calculate the germination rate for each type of seed using the following formula:  Germination Rate (%) = (Number of seeds germinated / Total number of seeds planted) x 100 | | | | |
| **Monitoring Growth** | | | | | | | | | | |
|  | | [The Great Seed Showdown- Student Worksheet](https://docs.google.com/document/d/17SVXHE-0HVpVHqbiNmyxIbNQ1_7dvloSzx6pc6RJ_fE/edit?usp=sharing)  Rulers | | | | **Plant Growth:** Continue to observe and record the growth of the soybean plants in both pots every 2-3 days for 18 days  **Measurements:** Measure and record the height of each plant (from base to the highest point) in centimeters (cm), overall plant appearance (healthy, weak, etc.) and the number of leaves on each plant.If you are using a soil moisture sensor include these measurements as well.  **OPTIONAL:** On the last day, pull each of the plants out carefully and measure and record the root lengths. Make qualitative observations about the root structure. | | | | |
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| **Lesson 3: Analysis** | | | | | | | | | | |
| 10 mins | | [The Great Seed Showdown- Student Worksheet](https://docs.google.com/document/d/17SVXHE-0HVpVHqbiNmyxIbNQ1_7dvloSzx6pc6RJ_fE/edit?usp=sharing) | | | | Guide the students to calculate the average growth for each of the seed types and to then graph them, | | | | |
| 10 mins | | [The Great Seed Showdown- Student Worksheet](https://docs.google.com/document/d/17SVXHE-0HVpVHqbiNmyxIbNQ1_7dvloSzx6pc6RJ_fE/edit?usp=sharing) | | | | Have the students share their results with the whole class and discuss why results may differ (if they do). | | | | |
| 10 mins | | [The Great Seed Showdown- Student Worksheet](https://docs.google.com/document/d/17SVXHE-0HVpVHqbiNmyxIbNQ1_7dvloSzx6pc6RJ_fE/edit?usp=sharing) | | | | Allow students time to complete the analysis questions in their student Worksheet. | | | | |
| 10 mins | | [The Great Seed Showdown- Student Worksheet](https://docs.google.com/document/d/17SVXHE-0HVpVHqbiNmyxIbNQ1_7dvloSzx6pc6RJ_fE/edit?usp=sharing) | | | | Allow students time to complete their Claims- Evidence - Reasoning - Justification after reviewing with them the criteria. | | | | |
| 5 mins | |  | | | | Conduct a class discussion about what went well with this experiment and what the challenges were. | | | | |
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| **Lesson 4: Engineering Challenge** | | | | | | | | | | |
| 10 mins | | [The Great Seed Showdown- Student Worksheet](https://docs.google.com/document/d/17SVXHE-0HVpVHqbiNmyxIbNQ1_7dvloSzx6pc6RJ_fE/edit?usp=sharing) | | | | Introduce the Engineering Design Challenge:  Challenge: You are an agricultural engineer tasked with developing a solution to a specific problemfaced by soybean farmers.  Share the Problem Options:  **Pest Invasion**: A new and particularly destructive insect has emerged, threatening soybean crops. Design a GMO soybean that is resistant to this specific pest.  **Drought Conditions:** Many soybean-growing regions are experiencing increasingly dry weather. Design a GMO soybean that can thrive with less water.  **Nutrient Deficiency:** The soil in some areas lacks essential nutrients needed for soybeans to grow optimally. Design a GMO soybean that can obtain the missing nutrients more efficiently.  Explain the Design constraints   * You can only modify a single trait in the soybean plant. * Your solution must be scientifically feasible, considering current GMO technology and plant biology. * You need to consider the potential impact of your GMO soybean on the environment and human health. | | | | |
| 20 mins | | Computer access | | | | Allow the students time to complete the design process:  **Research**: Research the chosen problem and current GMO technology.  **Brainstorm:** Brainstorm potential solutions as GMO soybeans.  **Prototype:** Develop a clear and labeled model of the GMO soybean, highlighting the modified trait.  ***If students are struggling, share these examples:***  **Example 1:**  Problem: The Spotted Lanternfly, a new and destructive invasive insect, has arrived in soybean-growing regions. It devours soybean leaves, significantly impacting crop yield.  Design Solution: Students might design a GMO soybean that produces a natural pesticide specifically targeting the Spotted Lanternfly but harmless to other beneficial insects. Their model could show a modified gene that instructs the plant to produce a protein that disrupts the Lanternfly's digestive system.  Scientific Feasibility: Scientists are already exploring ways to use RNA interference (RNAi) technology to target specific pests. Students could research this and explain how their GMO design incorporates a similar approach.  Impact Consideration: Students might consider the potential for the natural pesticide to harm other insects or disrupt the ecosystem. They could propose solutions like developing a targeted release mechanism for the pesticide within the plant itself.  **Example 2: Drought Conditions**  Problem: Many soybean-producing areas are experiencing increasingly dry weather, leading to crop failure due to water scarcity.  Design Solution: Students could design a drought-resistant GMO soybean. Their model might show a modified gene that allows the plant to utilize water more efficiently, perhaps by improving root structure or reducing water evaporation from leaves.  Scientific Feasibility: Scientists are currently researching genes that control drought tolerance in plants. Students could explore these advancements and explain how their design incorporates a similar gene modification.  Impact Consideration: Students might need to consider if their drought-resistant soybean would require less water overall or simply be more efficient with the water available. This could impact irrigation practices and water usage in agriculture. | | | | |
| 15 mins | | [The Great Seed Showdown- Student Worksheet](https://docs.google.com/document/d/17SVXHE-0HVpVHqbiNmyxIbNQ1_7dvloSzx6pc6RJ_fE/edit?usp=sharing) | | | | Have the students present their design to the class, explaining the solution, its benefits, and how it addresses the constraints. | | | | |
| **Differentiation**  **For students who need additional support:**   * **Graphic Organizers:** Provide students with graphic organizers to compare and contrast GMO and non-GMO soybeans. This visual aid can help them structure their understanding of the key concepts. * **Focus on Benefits:** For students who struggle with complex scientific concepts, focus on the benefits of GMOs in soybeans. Provide real-life examples of how GMO soybeans can help farmers or the environment. * **Model Building:** Use manipulatives like beans or blocks to represent plant cells and DNA. Students can physically model the process of inserting a gene into a plant cell.   **For students who need additional challenges**:   * **Debate Time!** Hold a structured classroom debate on the use of GMOs. Students can research and present arguments for and against GMOs, considering scientific evidence, ethical concerns, and economic factors. * **GMO in the News:** Have students research current events related to GMOs. They can present their findings to the class, discussing the social and ethical implications of these advancements. * **The Future of Food**: Challenge students to design a GMO solution for a specific agricultural problem. This could involve creating a disease-resistant crop or a plant with enhanced nutritional value. | | | | | | | | | | |
| **Extension**   * **Weed Killers:** Have the students plant seeds for GMO and non-GMO seeds along with "weed seeds" (recommend either gathering seeds from the wild or using any other fast germinating garden seeds). Wait until soybeans and weeds have germinated and soybeans have grown to 4 inches, then spray with glyphosate (RoundUp) at label rates. What happens? * **Soybean Life Cycle**: Expand the lesson by exploring the complete life cycle of a soybean plant, from seed to harvest. Students can research and present their findings on the different stages of growth and how GMOs might affect each stage. * **The Big Picture:** Connect the concept of GMO soybeans to the larger discussion of genetic modification. Explore how GMOs are used in other foods or medicines, and discuss the ethical considerations involved. * **Get Creative!**: Have students design a poster, infographic, or short video campaign to inform the public about GMOs and non-GMO soybeans. They can focus on the benefits, address concerns, or promote informed decision-making. * **Check out** [The Science of GMOs lesson](https://agclassroom.org/matrix/lesson/598/) for additional Lessons and background | | | | | | | | | | |
| **Assessment**   | **Lab Report** | | | | | | --- | --- | --- | --- | --- | | **Criteria** | **4 - Exemplary** | **3 - Proficient** | **2 - Developing** | **1 - Beginning** | | **Variables** | Accurately identifies the independent, dependent, and controlled variables in the experiment. | Identifies some variables but may be confused or lack clarity. | Mentions variables but inaccurately identifies their roles. | Does not identify the variables. | | **Hypothesis** | Clearly states a testable hypothesis | Hypothesized relationship between the variables and the predicted results is reasonable | Hypothesis uses the IF ..THEN format but is vague or incomplete | Hypothesis does not use the IF…THEN statement | | **Data Collection** | All data is accurately  recorded | Most data is accurately  recorded | Some inaccuracies in data  recording | Major inaccuracies or missing data  in the data table | | **Graph** | Graph is accurately  constructed and well constructed | Graph is mostly accurate  and well-constructed | Some inaccuracies in graph construction | Major inaccuracies or missing graph  construction | | | | | | | | | | **Analysis Questions** | Thorough and insightful  responses demonstrating  deep understanding of  concepts and implications | Adequate analysis with  some insightful points  Clear understanding of  concepts and implications | Superficial analysis with  limited insight | Minimal or no analysis; demonstrates  lack of understanding | | | | | | | | | | **Claims-Evidence-Reasoning- Justification** | | | | | | **Criteria** | **Level 4 (Exemplary)** | **Level 3 (Mastery)** | **Level 2 (Emerging)** | **Level 1 (Developing)** | | **Claim** | The claim is clear, focused, and takes a strong stance on the issue (e.g., GMO soybeans are beneficial/harmful). | The claim is clear and focused on the specific issue of GMO vs. non-GMO soybeans. | The claim is stated but lacks focus or direction. | The claim is unclear or not stated. | | **Evidence** | Strong and relevant evidence is provided | Relevant evidence is provided but limited in scope or depth. | Evidence is provided but is irrelevant or weak. | No evidence is provided to support the claim. | | **Reasoning** | The reasoning is well-developed, explaining how the evidence supports the claim and addresses counter-arguments. | The reasoning connects the evidence to the claim in a clear and logical way. | The reasoning is somewhat present but poorly explained or unconvincing. | The reasoning behind the evidence is absent or illogical. | | **Justification** | The justification is thorough and insightful, demonstrating a clear understanding of the issue and potential complexities. | The justification adequately explains why the evidence and reasoning support the claim. | Justification is attempted but lacks depth or clarity. | Justification for the claim based on the evidence and reasoning is absent. | | **Engineering Design Challenge** | | | | | | **Criteria** | **Level 4 (Exemplary)** | **Level 3 (Mastery)** | **Level 2 (Emerging)** | **Level 1 (Developing)** | | **Problem Understanding** | Demonstrates a deep understanding of the problem, considering its complexities and potential long-term effects. | Clearly defines the problem and its significance for soybean production | .Demonstrates some understanding of the chosen problem but lacks details. | Limited understanding of the chosen problem and its impact on soybean farmers. | | **Design Creativity** | Develops a highly innovative and well-defined GMO soybean design, considering alternative approaches. | Proposes a creative and well-developed solution with a clear modification to address the problem. | Presents a basic design solution with limited modification of the soybean plant. | Design solution lacks originality and innovation. | | **Scientific Feasibility** | Demonstrates a thorough understanding of GMO technology and plant science, creating a highly feasible and scientifically sound modification. | Applies scientific principles to the design, demonstrating a feasible modification for the chosen trait. | Design solution shows some understanding of GMO technology but lacks scientific accuracy. | GMO modification is unrealistic or contradicts basic plant biology. | | **Impact Consideration** | Provides a comprehensive and insightful analysis of potential impacts, suggesting mitigation strategies for any potential risks. | Analyzes potential environmental and health impacts, demonstrating awareness of both benefits and risks. | Mentions potential impacts but lacks detail or critical analysis. | Fails to consider potential environmental or health impacts of the GMO soybean. | | **Presentation Clarity** | Delivers a well-organized and engaging presentation, clearly explaining the design, model, and its benefits. | Presents a clear and organized explanation of the design, including a well-labeled model. | Model and explanation are somewhat presented but lack detail or organization. | Presentation is unclear or lacks essential information. | | | | | | | | | | | |