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| **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? | | | | |
| **Hypothesis:** | | | | |
| **Identify the following variables**  **Independent:**  **Dependent:**  **Controls:**  **Constants:** | | | | |
| **Materials**   * 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 * Optional: grow lights (if planting indoors) * Optional: Moisture sensors | | | | |
| **Procedure:**   1. **Label** your containers with the seed number and their group names. 2. **Preparation**: Divide the potting soil evenly between the two containers. Moisten the soil lightly with a spray bottle. 3. **Planting:** Label each pot "GMO" and "Non-GMO." Plant 5 GMO seeds in one pot and 5 Non-GMO seeds in the other pot, spacing them evenly with some distance between them. Plant all of the seeds at the same depth. 4. **Watering:** Gently water the soil again to settle the seeds. 5. **Placement:** Place the pots in a sunny location indoors (or under grow lights) at room temperature   **Observation**: You will observe the pots daily, keeping the soil moist but not soggy. TRecord this in their data chart in the Student Workbook.  **Germination Rate:**  Count the number of seeds that germinate (sprout) in each pot within 10 days. 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**   | **Seed** | **Number of seeds planted** | **Date first germinated** | **# of seeds germinated in 10 days** | **Germination rate** | | --- | --- | --- | --- | --- | | **1** |  |  |  |  | | **2** |  |  |  |  |   **Monitoring Growth**  **Plant Growth**: Continue to observe and record the growth of the soybean plants in both pots every 2-3 days until you have at least 5 dates recorded.  **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.   | **Seeds #1** | | | | | | --- | --- | --- | --- | --- | |  | Date | Height (cm) | Number of Leaves | Overall plant appearance (healthy, weak, etc.) | | Plant #1 |  |  |  |  | |  |  |  |  | |  |  |  |  | |  |  |  |  | |  |  |  |  | |  |  |  |  | |  |  |  |  | |  |  |  |  | |  |  |  |  | |  |  |  |  | |  | | | | | | Plant #2 |  |  |  |  | |  |  |  |  | |  |  |  |  | |  |  |  |  | |  |  |  |  | |  |  |  |  | |  |  |  |  | |  |  |  |  | |  |  |  |  | |  |  |  |  | |  | | | | | | Plant #3 |  |  |  |  | |  |  |  |  | |  |  |  |  | |  |  |  |  | |  |  |  |  | |  |  |  |  | |  |  |  |  | |  |  |  |  | |  |  |  |  | |  |  |  |  | |  | | | | | | Plant #4 |  |  |  |  | |  |  |  |  | |  |  |  |  | |  |  |  |  | |  |  |  |  | |  |  |  |  | |  |  |  |  | |  |  |  |  | |  |  |  |  | |  |  |  |  | |  | | | | | | Plant #5 |  |  |  |  | |  |  |  |  | |  |  |  |  | |  |  |  |  | |  |  |  |  | |  |  |  |  | |  |  |  |  | |  |  |  |  | |  |  |  |  | |  |  |  |  | | | | | |
| **Seeds #2** | | | | |
|  | Date | Height (cm) | Number of Leaves | Overall plant appearance (healthy, weak, etc.) |
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| **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.   | **Seed #1** | | | | --- | --- | --- | |  | **Root length** | **Qualitative observations** | | **Plant #1** |  |  | | **Plant #2** |  |  | | **Plant #3** |  |  | | **Plant #4** |  |  | | **Plant #5** |  |  | | **Seed #2** | | | |  | **Root length** | **Qualitative observations** | | **Plant #1** |  |  | | **Plant #2** |  |  | | **Plant #3** |  |  | | **Plant #4** |  |  | | **Plant #5** |  |  | | | | | |
| **Graphing**  Add the final growth heights for plants in Seed #1 and average it: \_\_\_\_\_\_\_\_\_\_  Add the final growth heights for the plants in Seed #2 and average it : \_\_\_\_\_\_\_\_\_\_\_  Create a bar graph for the average height grown for each of the seeds. | | | | |
| **Analysis**   1. **Did all of your Seed #1 seeds germinate and grow? Explain.** 2. **Did all of your Seed #2 seeds germinate and grow? Explain.** 3. **Compare the growth rates of the plants of Seed #1 and the plants of Seed #2.** 4. **Were there differences between your plants’ growth and the plants of your classmates? Describe.** 5. **Was your hypothesis proven? Explain.** 6. **If you could redo this experiment what would you do differently and why?** | | | | |
| **Create a Claims -- Evidence -- Reasoning-- Justification** that answers our 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?  **Claim :** Must be scientifically accurate and answer the question  **Evidence**: Include the scientific data you collected that supports the claim. Be sure to use the correct units.  **Reasoning**: Clearly link the evidence and the claim    **Justification:** Explain why this information is important to understand. | | | | |
| **Engineering Design Challenge**  **Challenge: You are an agricultural engineer tasked with developing a solution to a specific problem faced by soybean farmers.**  **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.   **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.   **Which problem did you choose and why?**  **Brainstorm at least three different options for modifying the soybean to solve the problem you chose.:**  **Which idea did you choose? Why did you choose this one?**  **Did you find any examples of this already happening when you did your research?**  **What impact would this have on the environment?**  **Draw a model of what the soybean that is altered in this way would look like.** | | | | |
| Allow the students time to complete the design process:  **Research**: Research the chosen problem and current GMO technology.  **Brainstorm:** Sketch and brainstorm potential solutions as GMO soybeans.  **Prototype:** Develop a clear and labeled model of the GMO soybean, highlighting the modified trait. | | | |  |