Crops Unit, Packet 1.3

First & Last Name: _____ Period/Hour:_____

NOTE: Packets are due after completing Part 5. Check each page to be sure all blanks are completed.

Driving Question: How do we design plant experiments?

Anchoring Phenomenon: In this packet, we will use systematic scientific practices to collect data and determine whether our hypothesis is correct. You will choose a specific change to a previous experiment (leaf discs) and measure how it affects the rates of photosynthesis.

Deeper Questions

1. How do scientists systematically collect and organize data?
2. How do our results compare to our hypotheses? And how do we know if our results are valid and reliable?
3. How can we explain the outcomes of our experiment using our understanding of atoms and molecules?

Schedule

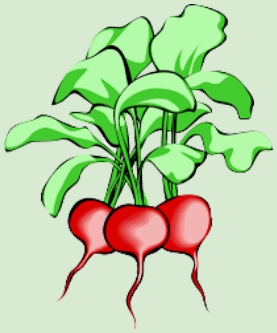
Part 1: Introduction
- Planning & Carrying Out an Investigation

Part 2: Data Collection
- What conclusion is supported by our data?

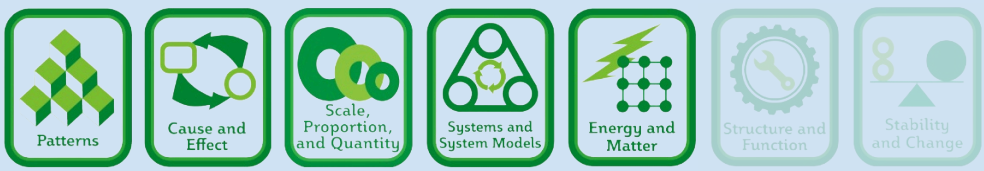
Part 3: Analysis
- How can we explain our results?

Part 4: Review & Assessment
- Science Writing, Review, and Assessment

Part 5: Career Connections
- Peer Review



AFNR Standards: PS.01.01. Determine the influence of environmental factors on plant growth. PS.02.03. Apply knowledge of plant physiology and energy conversion to plant systems. BS.02.01. Read, document, evaluate and secure accurate laboratory records of experimental protocols, observations and results. CRP.02.02. Use strategic thinking to connect and apply technical concepts to solve problems in the workplace and community. CRP.07.02. Evaluate the validity of sources and data used when considering the adoption of new technologies, practices and ideas in the workplace and community. CRP.08.02. Investigate, prioritize and solve problems in the workplace and community.
NGSS Standards (*PEs* & *CCCs are summarized below. SEPs are noted throughout the packet*). HS-PS1-7. Atoms and mass are conserved during reactions. HS-LS1-5. How photosynthesis transforms light energy into stored chemical energy.



Semester Schedule

1. Crops Unit
1.1: How can we improve crop productivity?
1.2: How can we explain crop growth using atoms?
1.3: How do we design plant experiments?

2. Livestock Unit
2.1: Why do different types of livestock need different feed?
2.2: How do digestive tracts of livestock differ?
2.3: How do we design animal experiments?

3. Genetics Unit
3.1: How can we predict genetic inheritance?
3.2: How do genetic outcomes vary in more complex cases?
3.3: How do we design genetic experiments?

4. Biotech Unit
4.1: How can DNA be modified to enhance species?
4.2 How do we design biotech experiments?

5. Sustainability Unit
5.1: What determines if food production is sustainable?
5.2: What methods improve sustainability in agriculture?
5.3: How do we design sustainability experiments?

These materials were partly developed with assistance from artificial intelligence.

Resource Links: Class Website; Research Slides Template;

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Part 1: Planning & Carrying Out an Investigation (1.3.1)

Overview: you will choose a specific change to the previous experiment and measure how it affects the rates of photosynthesis (based on the differences in how quickly the disks rise). Potential changes could include…

- How different intensities of light affect rates of photosynthesis
- How different colors of light affect rates of photosynthesis
- How different temperatures affect rates of photosynthesis
- How different pH levels affect rates of photosynthesis
- Alternate option of your choosing (requires approval by your instructor)

Materials needed (per group): A 10+ cc syringe, tap water, spinach leaves, paper punch, 20% sodium bicarbonate (baking soda) solution, light source, ruler, choice of independent variable.

Research Question - *What are we wondering? What do we want to figure out?*
SEP: Asking questions (for science) and defining problems (for engineering).,

1. What question were you trying to answer with your experiment? Reach a consensus as a group or class and record a **research question** below.

   We wonder if _____

   _____

Hypothesis, Rationale, Variables, etc. - *Make a testable prediction based on evidence.*
SEP: Planning and carrying out investigations; Developing & using models.

2. Turn your **research question** into a **hypothesis**. A hypothesis is like a guess or a prediction – it is how you would answer your research question based on your existing knowledge. Fill in the blanks below:

   We predict that _____

   _____

3. Now provide a **rationale** for your hypothesis. A rationale states why you think your hypothesis might be right; it provides some evidence and/or logic that supports the validity of your hypothesis.

   We think this because: _____

   _____

   _____

   Note: it's totally ok if your hypothesis ends up being wrong. Either way we'll gain more info. We just need to take a stance for now.

4. Every experiment has two important components: a **dependent variable** & an **independent variable**.

   An **independent variable** is the thing you purposely changed to test your hypothesis and answer your research question. Generally speaking, an experiment should only have one independent variable.

   What is your independent variable? _____

   A **dependent variable** is what you measure to answer your research question and determine if your hypothesis is correct. You can have multiple dependent variables as long as they are relevant.

   What is your dependent variable(s)?_____

5. A **control** is a part of your experiment that does not receive any treatment so that we have something to compare to. It enables us to confirm if what we changed had any impact on the outcomes.

   In this experiment, what is your control? _____

6. **Sample size** and **trials** affect the validity of your findings. **Sample size** refers to how many points of data will be collected. **Trials** refer to the number of times you will repeat the experiment under the same conditions. The larger the sample size and the more trials you perform, the more useful and reliable your findings are for answering your research question.

   *What is your sample size (how many points of data are being collected)?*_____

   *How many trials did you have?*_____ *How might your sample size and number of trials affect the reliability of your findings?*_____

   _____

7. **Constants** are the conditions that are kept the same between each replicate. If possible, an experiment should *not* be performed under changing conditions. This would make it impossible to determine whether our results were affected by our independent variable or by other changes. This would make our results less useful for answering our research question.

   *What is being kept constant in this experiment?*_____

   _____

   _____

Part 2: Data Collection (1.3.2)

Methods & Materials - *How did you test your hypothesis?* *SEP: Planning and carrying out investigations.*

8. The instructions you followed the first time you completed this lab are shown below. In the space below, summarize how the methods you will be using this time will differ. *In this experiment, we'll…*

_____

_____

_____

_____

1. Prior to this lab, your instructor should soak the spinach leaves in water overnight in a refrigerator. Fresh, dark green spinach leaves will work best. Your instructor will also need to prepare a 20% sodium bicarbonate solution by mixing 20 g of baking soda in one liter of water. Add a drop of dish soap to this solution for more reliable results.
2. Using a paper punch, cut out 10-20 leaf disks from the freshest portions of the spinach leaves (extras are good to have in case you need them). Try to avoid veins, stems, and other non-leafy portions.
3. Add 10 leaf disks to your 10 cc syringe (if it is larger than 10 cc's, that is ok). Suck up 10 cc's of the sodium bicarbonate solution your instructor has provided.
4. Hold your finger over the end of the syringe. Pull back on the plunger as far as you reasonably can; you are creating a vacuum to suck the air out of the inside of the leaf disks. You should be able to visibly see air bubbles coming out of the disks.
5. As you are sucking the air out, sodium bicarbonate is going into the spongy layer of the leaf cells. This is how the cells will get the carbon dioxide needed for photosynthesis
6. Gently squirt out the sodium bicarbonate solution into a sink or beaker (whichever your instructor has provided). Suck up 10 cc's of untreated water.
7. Make sure the leaf disks sink in the water in the syringe. If not, remove the water and repeat the steps on the previous page until they do.
8. Move your syringes to a well-lit location. Record the start time here: _____
9. While waiting, start the questions in the next section. Occasionally turn & lightly agitate the syringe.
10. Record the time at which at least half of the disks have floated halfway to the top of the syringe (i.e. the time at which at least 5 disks are at 5 cc's or higher).

11. Time: _____Total time elapsed from start to this time: _____min
12. If time allows, repeat this experiment with a second set of 10 disks newly punched from fresh leaves.
13. Record the start time for your second trial of spinach leaf disks here:
14. Record the end time at which 5 or more disks reached 5 cc's or higher here: _____

15. Record the total time elapsed here: _____min. Finish the questions in the next section.

Results & Data - *What do our data indicate?*
SEP: Analyzing and interpreting data. Using mathematics and computational thinking.

1. **As a class, determine the time needed for photosynthesis for each treatment. To do so…**
    a. Add up the times needed per syringe in each treatment for your group.
    b. Divide each sum by the total number of data points.
    c. For example, if the data for a treatment were: 4.5, 5.0, 3.25, 4.75, 3.5, 3.0, then the sum is 24
    d. Then divide this value by the total number of data points 24 ÷ 6 = 4 min = avg time.

	Time (write as a decimal; e.g., 9 min, 30 sec = 9.5 min)	Class Avg
Control	_____ + _____ + _____ + _____ + _____ + _____ = _____	
Treated	_____ + _____ + _____ + _____ + _____ + _____ = _____	

2. **Now create a graph based on your class average data. First, label each axis on the graph on the next page. The x-axis is horizontal (*back & forth*); the y-axis is vertical (*up & down*).**
    a. Usually the independent variable (*what was changed*) is on the horizontal x-axis and the dependent variable (*what was measured in response*) is on the vertical y-axis.

3. **Next, determine the type of graph you are making.**
    a. Bar graphs work well for comparing changes in quantities, while line graphs work well for comparing changes over time.
    b. Each component should be labeled with the type of treatment (e.g., *treated* and *control*).

4. **Third, determine the scale (*range of numbers*) you will use on the y-axis (vertical axis).**
    a. Determine your highest and lowest values for the data you will be graphing.
    b. Your scale should be large enough to encompass all of the values of data but should also be small enough to make it easy to compare the differences in data.
    c. Usually your scale starts at zero (but does not need to).
    d. Values on the y-axis usually increase by the same amount with each line.

5. **Fourth, complete this graph based on the data you collected.**

6. **Finally, create a caption that explains what kinds of trends and patterns are present in this graph. Then explain what these trends indicate for your research question and hypothesis.**
    a. Often a caption includes phrases like “In this graph you can see” and “This indicates that”.

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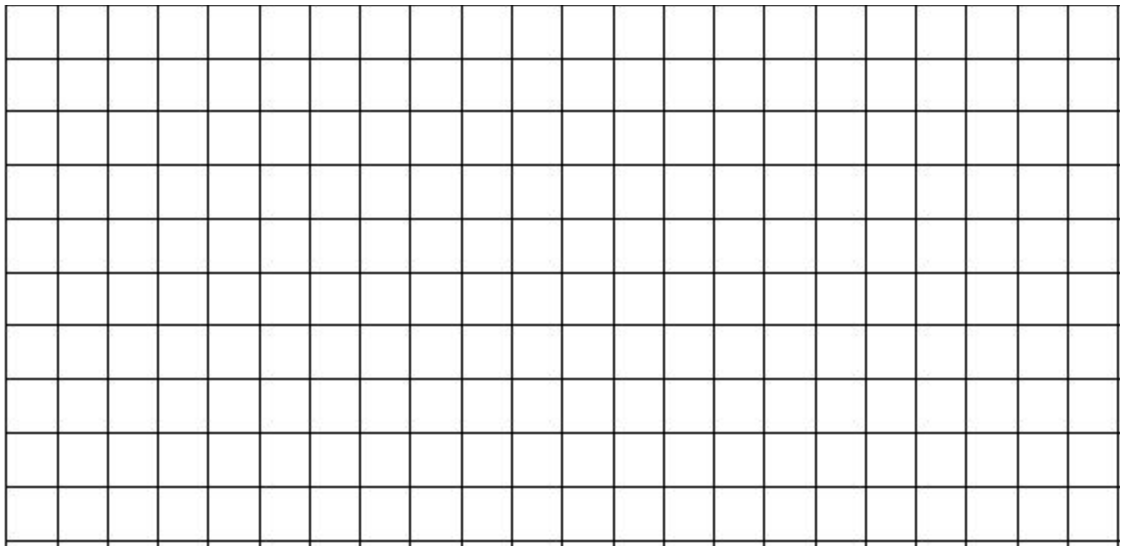

Figure 1: *This figure shows* _____

The key trend in this data is _____

This suggests that _____

_____

Part 3: Data Analysis (1.3.3)

Overview: You will determine whether your data support or refute your hypothesis, and develop explanations for if, how, and why your treatment affected photosynthesis.

Discussion & Conclusion - *Is our hypothesis supported by our data? How does this relate to our research question? What conclusions can we reach based on this investigation?*
SEP: Constructing explanations & designing solutions. Making evidence-based arguments. Obtaining, evaluating, & communicating information.

1. Restate your research question and hypothesis.

   We wondered if: _____

   _____

   We predicted: _____

   _____

2. Was your hypothesis supported by your data? Yes / No / Not sure (*circle one*).

   Explain: _____

   _____

   _____

3. Why do you think this outcome occurred? What was occurring at the cellular and molecular levels that would cause the results you observed in this experiment?

   _____

   _____

   _____

4. Are these results reliable & valid? How do you know? Would repeat trials have the same results?

   _____

   _____

   _____

5. What could we change to make our experiments have more valid and reliable findings?

   _____

   _____

   _____

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Part 4: Science Writing (1.3.4)

Overview: Effective communication is vital in science. Scientists must share their findings to allow others to build upon their work and make new discoveries. Scientists write using a standardized format to ensure consistency and predictability. This enables readers to locate specific information more quickly. You can see an example in Part 1 of this packet. Science writing includes the following components:

1. **Title**: a title includes the study subject, independent and dependent variables, and the outcome. Authors are usually listed alphabetically by last name below the title. You should also include your school.
2. **Abstract**: this is a summary of the entire publication. It summarizes key info as succinctly as possible.
3. **Introduction**: this summarizes the study subject, the research question (RQ), hypothesis, and rationale. It should also describe how the independent & dependent variables are related. It also provides a brief overview of the methods and how they relate to the RQ and hypothesis.
4. **Background Information**: these are the concepts & facts from credible sources to help the reader understand your work. All facts should be followed by parenthetical citation indicating the source [(Author, Year) (Smith, 2022)]. Include images or visual data to help your reader understand how changes at the cell or molecular level affect observable outcomes and changes.
5. **Methods & Materials**: this summarizes how the experiment was conducted. It should resemble a cookbook recipe with enough detail that others could replicate your work. Justify *how* your methods enable you to test your research question & hypothesis. Critique the effectiveness of your methods - how were they effective and how could they be improved?
6. **Results**: this provides all relevant data and observations from your experiment. It should also include at least one graph or table summarizing your data. A caption should describe trends and patterns data using ratios or percentages, and how these relate to the RQ and hypothesis. Both the x- and y-axis must be labeled. Explain if your data is reliable. Acknowledge your data's limitations for testing your hypothesis.
7. **Discussion & Conclusion**: First, restate your RQ & hypothesis, and explain whether your data support or refute your hypothesis. Then use data and evidence from your investigation and other sources to support your conclusions about the phenomenon you investigated and identify cause-and-effect relationships. Next, critique the strength of your evidence and conclusions and acknowledge their limitations. Conclude by proposing a solution to a problem using your data, evidence, and information. Consider alternative arguments/explanations/solutions and use evidence to critique their validity.
8. **Reference List**: this is the alphabetical list of all the sources used to create your paper. All sources used for this experiment should be cited using APA citation (*Last Name. First Name. (Year). Title. Source.*). Anything cited in this section should also be cited parenthetically (Author, Year) where it is mentioned in your presentation. For example, if you use research by J. M. Tisdall about soil organic matter, you would cite this in two places:
   1) A parenthetical citation after the sentence with the info: (Tisdall, 2020).
   2) A full citation in the References: Tisdall, J. M. (2020). Formation of soil aggregates and accumulation of soil organic matter. In *Structure and organic matter storage in agricultural soils* (pp. 57-96). CRC Press.

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Overview: Use your findings to create a presentation based on this template. You need all of the following

		5	4	3 - 0
1. Introduction	Criteria	Yes!!!	Kind of	Not Yet
1a	Create a testable research question (RQ) based on an authentic real-world phenomenon.			
1b	Develop a hypothesis based on the RQ that can be directly measured with data.			
1c	Provide a rationale for the hypothesis based on models, data, credible evidence, and/or reasoning.			
1d	Identify the independent variable (IV) & dependent variables (DV); explain the relationships between them.			
	Practices: Asking Questions. Planning & Conducting an Investigation, Crosscutting Concepts: Stability & Change	Total		/20
2. Background	Criteria	Yes!!!	Kind of	Not Yet
2a	Accurately summarize scientific information needed to understand the RQ and hypothesis.			
2b	Evaluate various sources of information and use only credible & accurate sources in project.			
2c	Properly cite all sources used in the project with both parenthetical *and* APA formats. Parenthetical: (Last Name, Year) APA: Last Name, First Name. (Year). Title. Source.			
2d	Communicate ideas effectively across multiple formats (written, visual, verbal, etc.).			
	Practices: Obtaining, Evaluating, and Communicating Information. Crosscutting Concepts: Structure & Function	Total		/20
3. Methods	Criteria	Yes!!!	Kind of	Not Yet
3a	Summarize the materials & methods so others could easily replicate the same experiment.			
3b	Explain how the methods specifically answer the RQ and test the hypothesis.			
3c	Critique the limitations of your methods (e.g., sample size, trials, authenticity, relevance to RQ, etc.).			
3d	If using a model, simulation, or model organism, summarize why it was chosen and how it effectively represents a more complicated phenomenon.			
	Practices: Planning & Conducting an Investigation. Crosscutting Concepts: Models	Total		/20
4. Results	Criteria	Yes!!!	Kind of	Not Yet
4a	Collect and analyze data and explain key trends and patterns across your data.			
4b	Create an effective visualization of your data (graph, chart, etc.) with labeled parts and a detailed caption.			
4c	Use mathematical functions (ratios, rates, percents, etc.) to make accurate conclusions about your data.			
4d	Acknowledge and explain the limitations of your data and its ability to address your RQ and hypothesis.			
	Practices: Analyzing and Interpreting Data, Mathematics and Computational Thinking. Crosscutting Concepts: Patterns; Scale, Proportion, & Quantity	Total		/20
5. Discussion	Criteria	Yes!!!	Kind of	Not Yet
5a	Restate your RQ & hypothesis, and explain whether your data support or refute your hypothesis.			
5b	Use data and evidence from your investigation and other sources to support your conclusions about the phenomenon you investigated and identify cause-and-effect relationships.			
5c	Propose a solution to a problem using your data, evidence, and credible information.			
5d	Consider alternative arguments/explanations/solutions and use evidence to critique their validity.			
	Practices: Constructing Explanations, Evidence-based Arguments. Crosscutting Concepts: Cause & Effect	Total		/20
6. General	Criteria	Yes!!!	Kind of	Not Yet
6a	Explain how environmental factors affect plant growth and development in a manner relevant to crop production considerations (PS.01.01) and consistent with conservation of matter & energy (HS-PS1-7).			
6b	Design solutions to improve crop productivity using plant physiology and energy conversion (PS.02.03) and confirm the validity of conclusions with valid sources (CRP.02.02, CRP.07.02).			
6c	Project is free of errors (factual, spelling, grammar, etc.) and reflects the work of adult professionals.			
6d	Students collaborated to evenly divide work, overcome obstacles, and effectively use time & resources.			
	Practices: Constructing Explanations, Evidence-based Arguments. Crosscutting Concepts: Structure & Function, Models, Patterns, Cause & Effect	Total		/20
Comments:		**Final Score:**		

Part 4: Review & Assessment (1.3.4)

Step 1: Review the content for this packet. Identify any concepts that are still unclear to you.
Step 2: Identify and discuss any remaining confusion with your instructor.
Step 3: Complete the Lesson Check (individually or small groups). Compare responses as a class.
Step 4: If your responses show more help is needed, your instructor will provide further support.

Part 5: Career Connections: Peer Review (1.4.5)

Overview: In small groups or individually, you will rank each other's contributions to your work. This will help you to better understand any strengths and weaknesses that might affect your job performance in the future.

Directions: Please evaluate your group as well as yourself on the basis of contributions and effort on a scale of 1 to 5. A group member who makes an outstanding contribution and did their best would receive a score of 5. A group member who did the bare minimum might score around a 3, and a group member who did little or nothing might get a one or a two. Provide a reason for your score – why did you give that score?

Group Member Name: _____ Score: 1 2 3 4 5 (*circle one*)

Reasoning for this score: _____

_____

Group Member Name: _____ Score: 1 2 3 4 5 (*circle one*)

Reasoning for this score: _____

_____

Group Member Name: _____ Score: 1 2 3 4 5 (*circle one*)

Reasoning for this score: _____

_____

Your Name: _____ Score: 1 2 3 4 5 (*circle one*)

Reasoning for this score: _____

_____

Packet 1.3 Lesson Check (1.3.4)

Name: _____Hour____Date:_____Score:_____

Directions: Your instructor will determine how you will submit your answers to the questions below. If they ask you to complete this in small groups, consider using a shared document to record your answers and ideas.

1. What question did the authors try to answer, and/or what problem did they seek to solve?

2. What was their hypothesis and research question?

3. Summarize the methods used to test their hypotheses and research questions.

4. Provide a summary of their findings; also, take a stance whether their specific conclusions are justified by the results.

5. How does this demonstrate the rigor and structured communication required in scientific writing?

6. In what ways does this article need to improve? Specifically consider the following:
    a. Is each major claim accompanied by a cited source? Do they properly cite their sources?
    b. Do they clearly state their research question(s), hypothesis, and rationale?
    c. Do their methods provide sufficient detail to enable others to replicate this work?
    d. Do their results include i) relevant figures that are appropriately labeled, and is this accompanied by ii) a convincing and credible interpretation of the data as it pertains to their research question?
    e. Do they address whether the conclusions are justified by the results, and do they provide a convincing argument as to how their conclusions are justified?
    f. Do they acknowledge their study design's limitations?
    g. Do they allow for the possibility of alternative explanations for their results?
    h. Do they address any potential biases or sources of error?

7. If you were asked to serve on a peer review committee, what would be your recommendations? Would you a) accept as is, b) accept with minor revisions, c) reconsider after major revisions, and d) reject? Why? Justify your stance with specific examples and reasoning.

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Title: The Impact of Crushed Eggshells on Radish Growth: A High School Experiment
Authors: Fingers, D; Thumb, G. (2023). Waterford Union High School, Waterford, WI.

Abstract: This study investigates the potential influence of crushed eggshells on the growth of radishes (*Raphanus sativus*). We conducted experiments to examine whether incorporating crushed eggshells into the soil can enhance radish growth in terms of mass gained. While the results exhibit some positive effects, the limitations of the experimental design must be considered.

Introduction: Radishes are commonly used in schools for research, making them an ideal subject for this experiment. We were unsure whether the addition of crushed eggshells to the soil could lead to increased radish growth, specifically in terms of mass gained. We suspected that the eggshell treatment would increase radish growth due to the calcium content of eggshells, which can contribute to soil enrichment (Smith et al., 2019). Calcium is known to play a vital role in plant development.

Methods:
- **Preparation of Eggshells**: We collected and cleaned eggshells, then crushed them into small pieces.
- **Radish Planting**: Radish seeds were sown in pots filled with potting soil mixed with varying amounts of crushed eggshells.
- **Data Collection**: Radishes were monitored over a six-week period, measuring their mass at the end of the experiment.

Results: Radishes grown with crushed eggshells had an average mass that was 5% greater than the average mass that was observed in a previous experiment involving radishes at the start of the semester.

Discussion: The results of our experiment indicate a modest increase in radish mass when eggshells were added to the soil. This suggests a potential positive effect on radish growth, aligning with our hypothesis. However, it's essential to acknowledge the limitations of our study, such as the small sample size and variability in environmental conditions. While our findings are promising, it's crucial to note that other factors, such as water and sunlight, also impact plant growth. Additionally, our research lacks a control group for a more robust comparison.

Conclusion: In conclusion, our experiment suggests that crushed eggshells may have a positive impact on radish growth in terms of mass gained. This finding aligns with our initial hypothesis, but it's important to recognize the limitations of our study, including the absence of a control group. Further research with a more controlled design is needed to draw definitive conclusions.

References:
Smith, A. *et al*. (2019). "The Role of Calcium in Plant Growth." *Journal of Plant Nutrition*, 45(3), 567-578.

Text Source: OpenAI (edited by C. Kohn) (2023). ChatGPT (version 3.5). This article was chosen because it is more feasible for students than an actual published scientific paper. If you feel capable, your instructor may allow you to use an actual peer reviewed article instead.

Crops Unit, Packet 4 Mastery Check (1.3.4)

Name: _____Hour____Date:_____Score:_____

Directions: Use the excerpt below to answer the following questions. Each sentence is numbered (e.g., (1) refers to the first sentence. Complete this assessment individually and then discuss it as a group and/or class.

Adrenaline Treatment Increases the Final Average Height of Radishes Compared to Control.

B. Badger, W. Wolverine, 6th Hour Agriscience, Waterford Union High School, Waterford, WI

Introduction: **(1)** The rate at which crops grow can affect the profitability of that crop (Fermer, 2023); the faster the crop grows, the more profitable a crop is for a farmer (Cropp, et. al, 2022). **(2)** We wondered if adding diluted adrenaline would increase the final average height of treated radishes after two weeks of growth. **(3)** We predicted that radishes treated with adrenaline would be taller after two weeks. **(4)** We thought this would be the case because of the effects that adrenaline has on the human body. **(5)** To test this hypothesis, we daily treated each radish seedling with 10 CCs of a solution containing 1 mg of adrenaline diluted in 2 liters of water. The control plants received 10 CCs of untreated tap water. After 2 weeks, we measured the heights of each radish and calculated the average of the experimental group and the control.

1. What is the **Independent Variable** in this experiment?
   a. Radishes b. The addition of adrenaline c. The final average height d. The radishes w/o adrenaline
2. What is the **Dependent Variable** of this experiment?
   a. Radishes b. The addition of adrenaline c. The final average height d. The radishes w/o adrenaline
3. What is the **Control** for this experiment?
   a. Radishes b. The addition of adrenaline c. The final average height d. The radishes w/o adrenaline
4. Which sentence contains the **Hypothesis**?
   a. 1 b. 2 c. 3 d. 4 e. 5
5. Which sentence contains the **Research Question**?
   a. 1 b. 2 c. 3 d. 4 e. 5
6. Which sentence contains the **Rationale**?
   a. 1 b. 2 c. 3 d. 4 e. 5
7. Which sentence contains the **Background Information**?
   a. 1 b. 2 c. 3 d. 4 e. 5
8. In what section would they include a graph of this data?
   a. Introduction b. Methods c. Results d. Discussion e. Reference List
9. In what section should they discuss whether their data support or refute the hypothesis?
   a. Introduction b. Methods c. Results d. Discussion e. Reference List
10. In what section would they find detailed steps for how we conducted this experiment?
    a. Introduction b. Methods c. Results d. Discussion e. Reference List
11. The sources of the facts in this introduction are cited in parentheses. Because of this…
    a. We don't need a reference list/bibliography
    b. We also need to cite these sources in the reference list/bibliography
    c. We need a reference list/bibliography, but only for sources not cited in parentheses.

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