Packet 3.3 - Plants Unit

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 can we investigate plant growth and function?

Anchoring Phenomenon: Throughout this unit, we have explored how plant cells function. We explored how plants can use water and carbon dioxide to produce glucose, and how enzymes can change glucose into other molecules. In this unit, we will explore this more deeply through an investigation that compares growth in treated and untreated plants.

Deeper Questions

1. How do scientists design experiments to answer questions?
2. How can we analyze data to identify patterns and develop explanations?
3. How do scientists communicate their ideas using standardized formats?

Schedule

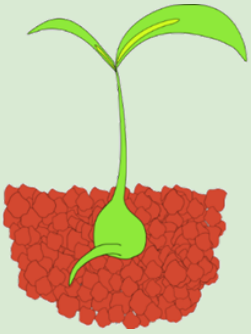
Part 1: Introduction
- Review of Core Ideas
- Planning & Carrying Out Investigations

Part 2: Data Collection & Analysis
- Data Collection
- Analyzing Data

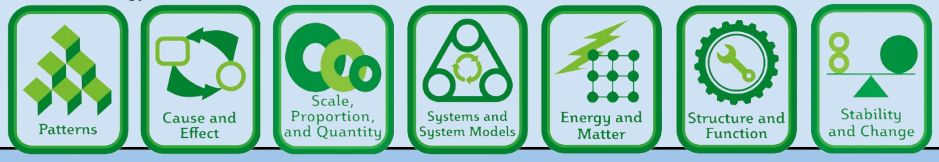
Part 3: Scientific Writing
- How Scientists Communicate
- Project & Presentation Checklists

Part 4: Work Time
- Preparing Your Presentation and Peer Review

Part 5: Review & Assessment
- Presenting Your Findings
- Mastery Check - Planning & Carrying Out an Investigation



NGSS Standards (*PEs* & *CCCs are summarized below. SEPs are noted throughout the packet*).
HS-LS1-2. Organization of interacting systems in multicellular organisms. HS-LS1-6. How carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules. HS-LS1-5. How photosynthesis transforms light energy into stored chemical energy. HS-LS1-7. Cellular respiration is a chemical process whereby food molecules and oxygen molecules form new compounds resulting in a net transfer of energy.



Semester Schedule

1. Matter & Energy
1.1: What happens when something burns?
1.2: How does burning change matter & energy?
1.3: Unit Assessment

2. Animals
2.1: How do animal cells use food?
2.2: What happens to food when it is consumed?
2.3: How do cells acquire atoms from food?
2.4: Unit Assessment

3. Plants
3.1: How do plant cells differ from animal cells?
3.2: How do plant cells obtain matter and energy?
3.3: How can we investigate plant growth and function?
3.4: Unit Assessment

4. Ecosystems
4.1: Why do different places have different amounts of species?
4.2: How does human activity affect species?
4.3: Unit Assessment

These materials were partly developed with assistance from artificial intelligence.

Resources: Class Website; Core Ideas; Practice Example; Academic Integrity Video; Noodle Tools: Video 1 & Video 2; Research Presentation Template; Example Presentation; Science Writing;

Part 1A: Review of Core Ideas (3.3.1a)

Overview: In this activity, you will review key concepts from this unit to prepare for your investigation. You will work in small teams to answer the questions listed below. You should take notes in a notebook, on a dry erase board, or on scratch paper so that you are prepared to deliver your responses during the class discussion that will follow. Note: your instructor may assign specific questions to your group if time is limited.

3.1 Driving Questions - *Record your ideas separately (e.g., on a white board or scratch paper).*
SEP: Developing & Using Models

1. True/false: animal & plant cells function similarly and are made from the same macromolecules. Explain.
2. Do plant cells have mitochondria? What process occurs here? Why is this needed?
3. What are three organelles found in plant cells that are not found in animal cells?
4. What is a cell wall? What is cellulose? How do these affect plant function & plant cells?
5. What is a vacuole? What is its purpose and function in a plant cell?
6. What is a chloroplast? What process occurs here? Why is this needed for cell function?
7. Most of the glucose produced during photosynthesis is used for what purposes?
8. True or false: like animal cells, plant cells are organized into tissues, organs, and systems.
9. What is xylem? What's its purpose/function?
10. What is phloem? What's its purpose/function?
11. How do plants transport molecules like glucose and water without a heart to circulate fluids? Include: *xylem, phloem, evaporation.*
12. Plant cells in roots and stems lack access to light; how do they obtain glucose needed for cell respiration and other functions?

3.2 Driving Questions - *Record your ideas separately (e.g., on a white board or scratch paper).*
SEP: Developing & Using Models

1. How do plants acquire carbs, fats, & proteins if they cannot consume other organisms?
2. How do plant cells produce carbohydrates?
3. How do plant cells produce fatty acids?
4. How do plant cells produce amino acids?
5. How do the atoms in glucose and soil minerals relate to all the molecules found within a plant cell?
6. True or false: an enzyme has a completely different molecular structure after a reaction is completed. Explain.
7. How many different types of enzymes are found in plant cells? Why?
8. How do some enzymes assemble macromolecules from individual molecules?
9. How do some enzymes disassemble macromolecules into individual molecules?
10. How do enzymes enable species to interact with each other?
11. What are decomposers? Provide examples.
12. Why are decomposers important for species interactions?

Part 1B: Planning & Carrying Out an Investigation (3.3.1b)

Overview: You will use standard components of scientific investigations to organize your investigation and prepare for data collection.

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. An **independent variable** is what you change to test a hypothesis & answer your research question.

   What is your independent variable? _____

5. A **dependent variable** is what you measure to address your research question & hypothesis.

   What is your dependent variable(s)? _____

6. A **control** is a part of your experiment that does not receive any treatment. It provides a basis for comparison. This enables us to confirm if what we changed had any impact on the outcomes.

   In this experiment, what is your control? _____

7. **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 valid 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?*_____

   _____

8. **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?*_____

   _____

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

Materials: radish seeds; planting containers; potting soil; markers & tape or sticks for labeling.

Methods:

1. Determine how the soil or growing conditions will be changed for one six-pack seedling container of radishes. Keep the second container untreated as a control for comparison.
2. Add soil to the two six-pack containers until level with the top. Lightly pat down.
3. Create one small depression in the soil of each compartment.
4. Place one radish seed in each depression. Fill soil over the seeds and pat down gently.
5. Lightly water the soil until moist, not soaking.
6. Label each container with class info and move to the experiment location.

1. How are these methods effective for answering the research question and testing the hypothesis? How do these methods test the relationship between the independent and dependent variables?

   _____

   _____

   _____

2. In what ways are these methods limited or imperfect for answering the research question and testing the hypothesis? How could these methods be improved to get more accurate, valid, and reliable data?

_____

_____

_____

3. Is our model organism (radishes, *Raphanus sativus*) an effective choice for addressing the research question and testing the hypothesis? (*Hint: do radishes grow similarly to other plants? Are they mostly consistent from plant to plant? Are radishes fast growing, affordable, and widely available?*)

_____

_____

_____

Part 2: Data Collection & Analysis (3.3.2)

Overview: You will be collecting data to answer your research question and address your hypothesis.

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

Directions:

1. Acquire your group's experimental radishes.
2. Use a ruler with cm & mm measurements to determine the height of each radish plant.
    a. Place the ruler at the base of each plant.
    b. Gently stretch out the plant as far as it will go without breaking. Record the maximum distance the plant will stretch
3. Record the data for each plant in each container (treated & control) in the table provided in this section.
4. As a class, determine the average size of the plants for each treatment. To do so…
    a. Add up the measurements for each plant in each treatment for your group. Then divide each sum by the total number of data points.
        i. *For example, if the data for one container of radishes were: 4, 5, 3, 5, 4, 3 then the sum would be 4 + 5 + 3 + 5 + 4 + 3 = 24. Then divide this value by the total number of data points 24 ÷ 6 = 4. Your average plant height in this case is 4 cm.*
5. If feasible, measure the mass of each plant using a digital balance. Record the average mass for each treatment.

6. Record your data in the space below.

	Plant Height (cm)	Average Height for your Group	Class Avg
Control	____ + ____ + ____ + ____ + ____ + ____ = ____		
Treated	____ + ____ + ____ + ____ + ____ + ____ = ____		

	Plant Mass (g)	Average Mass for your Group	Class Avg
Control	____ + ____ + ____ + ____ + ____ + ____ = ____		
Treated	____ + ____ + ____ + ____ + ____ + ____ = ____		

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

Create a graph based on your instructor's guidance and the steps below.

1. **First, label each axis. 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*) is on the vertical y-axis.
2. **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*).
3. **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.
4. **Fourth, create a graph based on the data you collected.**
5. **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".

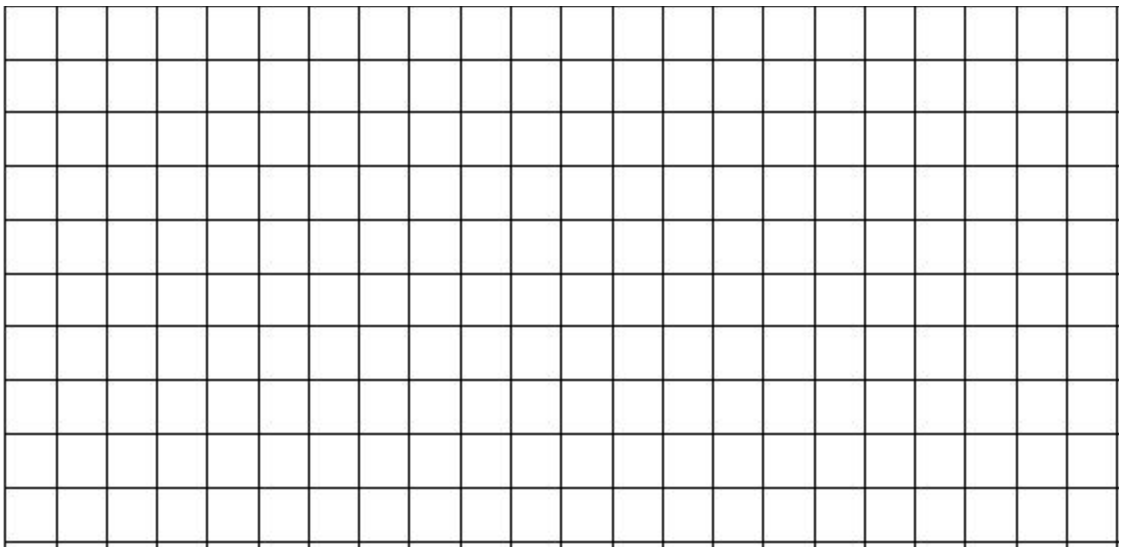


Figure 1: *This figure shows* _____

The key trend in this data is _____

This suggests that _____

_____

Questions: Discuss in small groups. Your instructor will determine how to record your ideas (e.g., whiteboards, scratch paper, online document, etc.). Prepare to discuss your ideas for each question. Determine who will serve each of the following roles for each question: *info seeker, summarizer, writer,* and *speaker*.

1. Summarize your findings using class averages. What trends or patterns did you observe? What were the key findings? Make your claims more precise by using mathematical functions (e.g., percents or ratios).
2. Critique the validity & reliability of this data. Is this enough to answer our research question once and for all? Is more data needed? Is better data needed? What limits the validity or reliability of our data?
3. Does this data support or refute your hypothesis? Is more information needed to make this determination? What alternative hypotheses or explanations might be possible?
4. Make a claim or develop a solution about the real-world phenomenon that we're studying (plant growth) and support it with data from this investigation.
5. How might the following factors affect the rate of plant growth? a) photosynthesis; b) cellular respiration; c) biosynthesis; d) cell enzymes; e) Availability of CO_2, H_2O, Soil Minerals, etc.
6. What would be the next steps for this work? What questions emerged that, if answered, would deepen our understanding of plant growth and development?

Your instructor may choose to meet with individual groups. If so, **raise your hand** when you are ready. Your instructor will listen to your responses. If you are ready to move on, they will sign below.

This activity was successfully completed _____ (*instructor signature*)

Part 3: Scientific Writing (3.3.3)

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 by clicking here. 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 cite information from Easton and Glauer about how plants grow, you would cite this information in two places:
    a. A parenthetical citation after the sentence with the info: (Easton & Glauer, 2021)
    b. A full citation in the References: Easton, J. Glauer, D. (2021). What Makes Plants Grow? *IFAS Extension - edis.ifas.ufl.edu*

Part 4: Scientific Writing Checklist (3.3.4)

Overview: Use your findings to create a poster, paper, or presentation. Your work needs <u>all</u> of the following.

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.			
1e	Explain how specific changes to this system (IV) affect outcomes/stability in this system (DV).			
	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. <u>Parenthetical</u>: (Last Name, Year) <u>APA</u>: Last Name, First Name. (Year). Title. Source.			
2d	Communicate ideas effectively across multiple formats (written, visual, verbal, etc.).			
2e	Explain how cell structures and/or molecular substances affected plant growth & development.			
	Practices: Obtaining, Evaluating, and Communicating Information, Crosscutting Concepts: Structure & Function	Total		/20
3. Methods	Criteria	Yes!!!	Kind of	Not Yet
3a	Provide a detailed materials list summarizing all items needed for this investigation.			
3b	Summarize the methods so others could easily replicate the same experiment.			
3c	Explain how the methods specifically answer the RQ and test the hypothesis.			
3d	Critique the limitations of your methods (e.g., sample size, trials, authenticity, relevance to RQ, etc.).			
3e	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	Assess the validity of your data using statistical methods (e.g., standard error) and/or by comparing with other credible sources of info & evidence.			
4e	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	Critique the strength of your evidence and conclusions and acknowledge their limitations.			
5d	Propose a solution to a problem using your data, evidence, and credible information.			
5e	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	Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy (HS-LS1-5).			
6b	Explain how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules (HS-LS1-6).			
6c	Explain how most glucose from photosynthesis is used for cell respiration to recharge ATP needed for cellular function, whereas leftover glucose is used for cellulose and other molecules (HS-LS1-7).			
6d	Explain how the hierarchical organization of plants (e.g., xylem, phloem, photosynthesis in leaves, respiration in all cells, etc.) enable it to function and gain mass (HS-LS1-2).			
6e	Project is free of errors (factual, spelling, grammar, etc.) and reflects the work of adult professionals.			
6f	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		/24

Peer Review Form

Name: _____ Date: _____ Hour: _____

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 would get a 3, and a group member who did nothing or almost nothing would get a 1 or 2. Provide a reason for your score – why did you give that score? *(5's need no reason)*

1. Group Member's Name: _____ Score: 1 2 3 4 5

Reason: _____

_____

2. Group Member's Name: _____ Score: 1 2 3 4 5

Reason: _____

_____

3. Group Member's Name: _____ Score: 1 2 3 4 5

Reason: _____

_____

4. Your Name: _____ Score: 1 2 3 4 5

Reason: _____

_____

Additional comments or concerns: _____

_____

_____

Changes you would recommend for this activity: _____

_____

_____