Lesson 3: Investigating Plants

Overview

Students conduct an investigation about plants in the light and dark and about mass changes. The focus of this lesson is to make observations and prepare data to be used as evidence for their explanations in Lessons 4 and 5.

Download PDF of Lesson 3 Teacher's Guide

Guiding Question

What happens when plants are left in the light and in the dark, and where does a plant's mass come from?

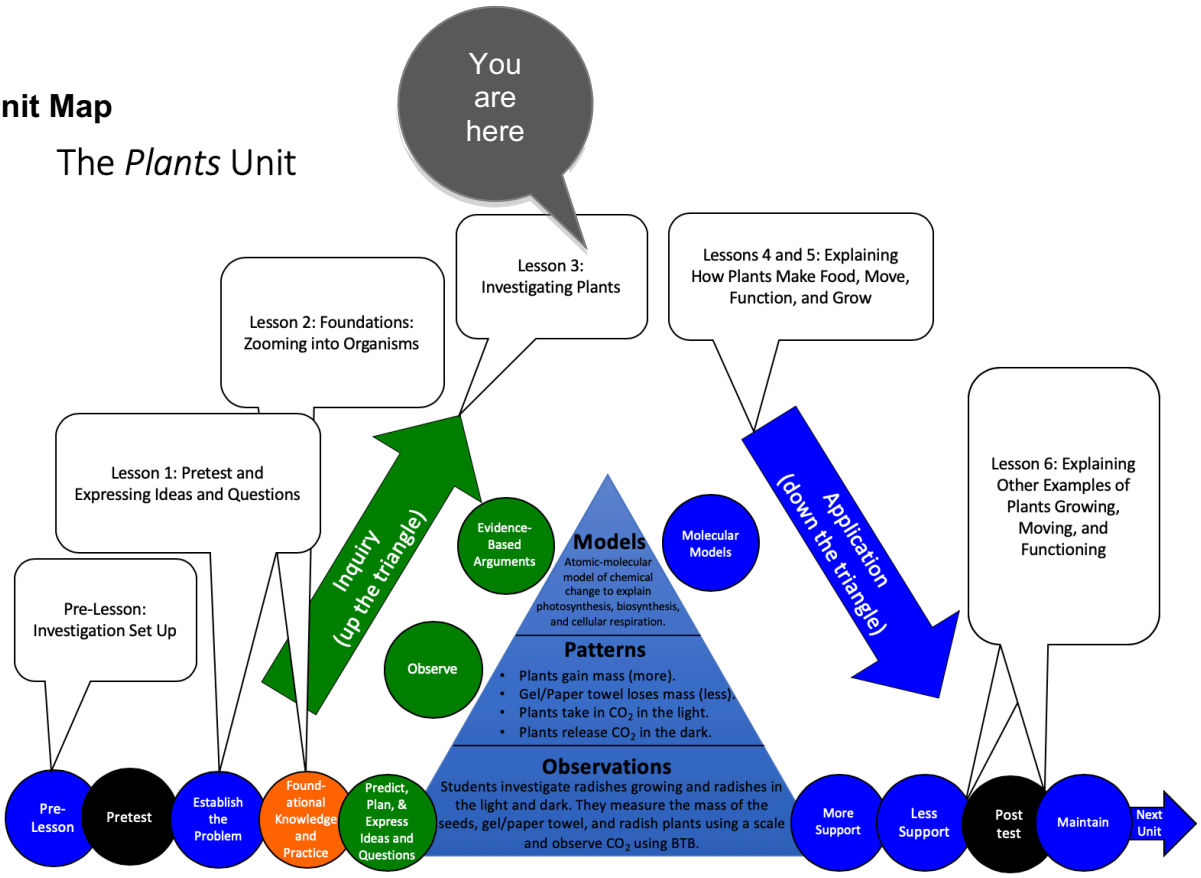
Activities in this Lesson

Note: There are two different pathways to choose from in Lesson 3. Please see the Plants Unit Front Matter and/or the Background Information section below for clarification in making this instructional decision.

- Activity 3.1: Predictions and Planning about Radish Plants Growing (50 min)
- Activity 3.2: (GL or PT): Observing Plants' Mass Changes, Part 1 (30 min)
- Activity 3.3: Observing Plants in the Light and Dark (60 min)
- Activity 3.4: (GL or PT): Observing Plants' Mass Changes, Part 2 (45 min)
- Activity 3.5: Evidence-Based Arguments About Plants (50 min)

Unit Map

The *Plants* Unit



Learning Goals

Target Performances

Activity	***Target Performance***
Lesson 3 – Investigating Growing Radish Plants (students as investigators and questioners)	
Activity 3.1: Predictions and Planning about Radish Plants Growing	Students develop hypotheses about how matter moves and changes and how energy changes when radishes move and grow and make predictions about how they can use their investigation tools—digital balances and BTB—to detect movements and changes in matter.
Activity 3.2 (PT or GL): Observing Plants' Mass Changes, Part 1	Students harvest their radish plants and dry down the plants and the paper towel or gel in preparation for Activity 3.4.
Activity 3.3: Observing Plants in the Light and Dark	Students observe how plants affect BTB in the light and dark, identify patterns in data, and reach consensus with other groups about their results.
Activity 3.4 (PT or GL): Observing Plants' Mass Changes, Part 2	Students measure the dry weight of harvested plants and of paper towels or gel, identify patterns in data, and reach consensus with other groups about their results.

Activity	*Target Performance*
Activity 3.5: Evidence-Based Arguments about Plants	Students (a) use data from their investigations to develop evidence-based arguments about how matter moves and changes and how energy changes when plants grow, move, and function; and (b) identify unanswered questions about matter movement and matter change that the data are insufficient to address.

NGSS Performance Expectations

Middle school

- MS. Structure and Properties of Matter. MS-PS1-1. Develop models to describe the atomic composition of simple molecules and extended structures.
- MS. Chemical Reactions. MS-PS1-2. Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.
- MS. Chemical Reactions. MS-PS1-5. Develop and use a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved.
- MS. Matter and Energy in Organisms and Ecosystems. MS-LS1-7. Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism.
- MS. Matter and Energy in Organisms and Ecosystems. MS-LS2-3. Develop a model to describe the cycling of matter and flow of energy among living and non-living parts of an ecosystem.

High school

- HS. Chemical Reactions. HS-PS1-4. Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.
- HS. Chemical Reactions. HS-PS1-7. Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.
- HS. Structure and Function. HS-LS1-2. Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.
- HS. Matter and Energy in Organisms and Ecosystems. HS-LS1-5. Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.

Background Information

Three-dimensional Learning Progression

This lesson provides students with experiences to observe and to collect data which will support them in their next lesson when they construct their explanations about photosynthesis and cellular respiration. They will observe that plants “breathe” (i.e., exchange gases with air) differently in the light and in the dark.

This lesson includes two PEO (Predict-Explain-Observe) Inquiry Activity Sequences with the final E (Explain) occurring in the next two lessons. We will consistently focus on the idea that understanding carbon-transforming processes involves answering the Three Questions:

- **The Matter Movement Question: Where are molecules moving?** (How do molecules move to the location of the chemical change? How do molecules move away from the location of chemical change?)
- **The Matter Change Question: How are atoms in molecules being rearranged into different molecules?** (What molecules are carbon atoms in before and after the chemical change? What other molecules are involved?)
- **The Energy Change Question: What is happening to energy?** (What forms of energy are involved? What energy transformations take place during the chemical change?)

The investigations in all units will make use of two essential tools:

- Digital balances. Students can detect movement of atoms (the Matter Movement Question) by measuring differences in mass. This Activity will ask students to harvest their plants to prepare for future dry massing.
- Bromothymol blue (BTB). This is a liquid indicator that changes from blue to yellow in response to high levels of CO_2. Thus, changes in BTB can partially answer the Matter Change Question by detecting whether there is a chemical change that has CO_2 as a reactant or product.

Key Ideas and Practices for Each Activity

Activity 3.1 is the **Predictions and Planning Phase** of the instructional model (beginning the climb up the triangle). During this phase, students record their predictions and express ideas about what happens to plants when they are in the light and the dark as well as where a plant's mass comes from as it grows. They use the **Predictions and Planning Tool** to do this.

Activity 3.2 will set up the **Observations Phase** of the instructional model for Activity 3.4. During this activity, the students will harvest their radish plants. If you are following the 2-turtle Gel Protocol, students will collect wet mass in 3.2 and set up to collect dry mass later in Activity 3.4. If you are following the 1-turtle Paper Towel Protocol, students will collect dry mass only in Activity 3.2. There are again two protocol pathways centered around the growing plants investigation for Lesson 3. These correspond to the 2-turtle (Gel Protocol) and 1-turtle (Paper Towel Protocol) that you chose in the Pre-Lesson. You will need to follow the same pathway you chose initially in order to remain consistent with the data collected from the beginning of the unit with the data students will collect here. See the Student Challenges and Teacher Choices in the Plants Unit document as a reminder.

Activity 3.3 is the first part of the **Observations Phase** of the instructional model (going up the triangle). During this phase, the students conduct the investigation for plants in the light and in the dark, record data, and try to identify patterns in their data and observations. The important practices students focus on in this activity are 1) making measurements and observations, 2) recording their data and evidence, and 3) reaching consensus about patterns in results. They use the **Observations Worksheet** and **Class Results Poster** to do this.

Activity 3.4 is the second part of the **Observations Phase** of the instructional model (going up the triangle). During this phase, the students conduct the investigation for plants growing by harvesting and drying their plants. The important practices students focus on in this activity are 1) making measurements and observation, 2) recording their data and evidence, and 3) reaching consensus about patterns in results. They use the **Observations Worksheet** and **Class Results Poster** to do this.

Activity 3.5 is the **Evidence-Based Arguments Phase** of the instructional model (going up the triangle). During this phase, the students review the data and observations from their investigations of plants and develop arguments for what happened during the investigations. In this phase, they also identify unanswered questions: at this point they have collected data and

observations about macroscopic scale changes (BTB color changes, mass changes), but they do not have an argument for what is happening at the atomic-molecular scale. They use the **Evidence-Based Arguments Tool** to record their arguments at this phase.

Plants are composed of materials that they get from air and soil minerals. Given the range of experiences young children may have with plants, it is interesting that most develop the same story about plant growth—that small seeds are planted in soil and, given water, grow into mature plants over the course of weeks and months. Sunlight is also necessary for plants to grow. It is no wonder that most students believe most plant mass comes from soil and water since these are the visible inputs they see given to plants.

Students are not completely wrong about soil and water. Much of a plant's total wet mass is actually water. This water contributes to short-term mass gain, but most water does not contribute to long-term building of the large organic molecules that are plant dry mass. The dry mass is carbon-based substances. This carbon does not come from soil or water, but rather from carbon dioxide taken in from the air. Scientists have traced specific carbon atoms (Carbon-14) from glucose back to CO_2. Scientists have also shown that most oxygen in glucose comes originally from CO_2. The O_2 plants give off comes mostly from water. Water does contribute some to biomass, through hydrogen atoms, which comprises a very small percentage of plant mass, but most of the atoms from water eventually leave the plant. Soil minerals—like nitrogen from ammonia—add to plant biomass (about 2% of dry mass) when incorporated into proteins inside the plant.

- **Air**—CO_2 in air contributes carbon (45% of dry mass) and oxygen (45% of dry mass)
- **Soil Minerals**—can potentially contribute nitrogen, phosphorous, calcium, magnesium, etc. (totaling about 4% of dry mass)
- **Water**—hydrogen atoms from water are about 6% of the plant's dry mass.

There are two pathways from which to choose when teaching this lesson, depending on which turtle trail you chose in the Pre-Lesson, as well as whether or not your students' plants seem ready at this point. See the Plants Unit Front Matter and the Student Challenges and Teacher Choices in the Plants Unit for more details.

A note on mass and weight: Grams and kilograms in the SI (metric) system are units of mass—the amount of matter in a system. On the other hand, pounds and ounces in the English system are units of weight—the force of gravity on a particular mass. As long as gravity doesn't change, these units are interconvertible: The force of gravity on a 1 kg mass is about 2.205 pounds. Since most American students are more familiar with the English units of weight, we sometimes use "weigh" and "weight," especially when encouraging students to express their own ideas. When referring to measurements in grams, we use "mass" as both a verb and a noun.

Key Carbon-Transforming Processes: Photosynthesis and Cellular Respiration

Content Boundaries and Extensions

Talk and Writing

At this stage in the unit, the students will complete the inquiry sequence for Plant Investigations—they will go up the triangle. This means they will go through the **Predictions and Planning Phase**, the **Observations Phase**, and the **Evidence-Based Arguments Phase**. The tables below show specific talk and writing goals for these phases of the unit.

Talk and Writing Goals for the Predictions Phase	Teacher Talk Strategies That Support This Goal	Curriculum Components That Support This Goal

Treat this as elicitation and brainstorming (like the Expressing Ideas and Questions Phase), but with more directed questioning.	*Now that we have set up the investigation, we want to predict what we think will happen to matter and energy.*	Three Questions Handout **Predictions and Planning Tool**
Elicit a range of student ideas. Press for details. Encourage students to examine, compare, and contrast their ideas with the ideas of other students.	*Who can add to that?* *What do you mean by _____? Say more.* *So I think you said _____. Is that right?* *Who has a different idea?* *How are those ideas similar/different?* *Who can rephrase _____'s idea?*	Investigation Video (selected sections)
Encourage students to provide evidence that supports their predictions.	*How do you know that?* *What have you seen in the world that makes you think that?*	
Have students document their ideas to revisit later.	*Let's record our ideas so we can come back to them and see how our ideas change.*	**Predictions and Planning Tool**

Activity 3.1: Predictions and Planning about Radish Plants Growing (50 min)

Overview and Preparation

Target Student Performance

Students develop hypotheses about how matter moves and changes and how energy changes when radishes move and grow and make predictions about how they can use their investigation tools—digital balances and BTB—to detect movements and changes in matter.

Resources You Provide

- (From previous lesson) Pre-Lesson 0.2 Plant Growth Investigation Worksheet
- (From previous lesson) 1.2 Expressing Ideas and Questions Tool for Plants Growing
- Time-lapse video of plants growing (http://www.youtube.com/watch?v=d26AhcKeEbE)

Resources Provided

- *Carbon TIME* Growing Plants Video
- 3.1 Predictions and Planning about Radish Plants Growing PPT
- 3.1 Predictions and Planning Tool for Plant Investigations (1 per student)
- 3.1 Assessing the Predictions and Planning Tool for Plant Investigations

Recurring Resources

- (Optional) BTB Color Handout (1 per group)
- Three Questions 11 x 17 Poster (1 per class)
- Three Questions Handout (1 per student)
- (Optional) Investigation Planning Tool

Setup

This lesson helps students prepare for the Plants Investigations (Activities 3.2-3.4). An optional aid for this lesson is to have a 'demo' investigation setup to show students what they will be doing in the next lesson. If you chose to do this, see the materials list in Activities 3.2 and 3.3. Another optional extension to this lesson is for students to plan their own investigations. If you choose to do this, you may or may not want to have extras of the materials on hand in case groups of students want a closer look at their available materials. Optionally, print a few copies of the BTB Color Handout for students to use as a color reference.

Refer to the BTB Information and Instructions Handout for information about preparing BTB.

Print one copy per student of the 3.1 Predictions and Planning Tool for Plant Investigations. Prepare your computer, projector, and speakers for the *Carbon TIME* Growing Plants Video and the 3.1 Predictions and Planning about Radish Plants Growing PPT. Print one copy of the Three Questions 11 x 17 Poster and display it on your classroom wall. Print one copy of the Three Questions Handout for each student. Retrieve the materials from Activity 1.2. This may include a PPT slide from the lesson in which you typed students' responses or a photograph of their sticky notes as well as the students' completed 1.2 Expressing Ideas and Questions Tool for Plants Growing.

Directions

1. **Use the instructional model to show students where they are in the course of the unit.**

Show slide 2 of the Predictions and Planning about Radish Plants Growing PPT.

2. **Introduce Lesson 3.**

Tell students that in this lesson, they will be investigating what happens when plants grow to learn more about what happens to matter *and energy* during chemical changes.

- Use the link in slide 3 of the PPT (or above) to watch the short time lapse video of plants growing to prepare students to think about the investigation.

3. **Review the Matter Movement Question.**

Display slide 4 of the PPT. Put a copy of the Three Questions 11 X 17 Poster on the wall for reference if it is not there already. Give each student one copy of the Three Questions Handout or have them take out their existing copies.

- Draw students' attention to the poster and point out that each question is accompanied with "rules to follow" as well as ways to "connect atoms to evidence."
- Have students highlight, underline, or box the following rule about matter: Atoms are bonded together in molecules.

4. **Review the Matter Change Question**

Display slide 5 of the PPT.

- Have students highlight, underline, or box the following rule about matter: Atoms last forever.

5. **Review the Energy Change Question**

Display slide 6 of the PPT.

- Have students highlight, underline, or box the following rules about energy: Energy lasts forever, and energy can be transformed.

6. **Show students the first section of the *Carbon TIME* Growing Plants video.**

Show slide 7 of the PPT.

- Watch the video until the first intermission where Darryl and Nina ask the students to make predictions about what happens when plants are in the light and in the dark (from 0:00 to about 2:30).
- Pause the video to discuss the questions posed on the screen before students complete the Predictions and Planning Tool.

7. Have students complete Part A of the Predictions and Planning Tool for Plants Growing.

Show slide 8 of the PPT. Pass out one copy of the 3.1 Predictions and Planning Tool for Plant Investigations to each student, and ask them to record their ideas as individuals for each of the Three Questions for plants growing

- Remind students that these are just *predictions*, and that there are no wrong answers at this point. Encourage them to write down all of their ideas on the tool.

8. Discuss the Matter Movement Question as it relates to a digital balance

Show slides 9 and 10 of the 3.1 Predictions and Planning about Radish Plants Growing PPT. Discuss with students how a digital balance can be used to measure matter moving into or out of a system. Highlight that the mass of the system can be measured before and after a change happens in a system. Discuss the two possible conclusions students can draw from their observations:

- If the mass of the system increases, then matter *must* have moved into the system (remember the facts about atoms)
- If the mass of the system decreases, then matter *must* have moved out of the system.

9. Discuss how to account for the dry mass of plants.

Show slide 11 of the 3.1 Predictions and Planning about Radish Plants Growing PPT. Discuss how water makes up a large portion of the mass of plants. If you are following the gel protocol, remind students of their previous learning about this in the pre-lesson.

- Have a discussion with students about their ideas about how they could measure just the mass of the plant that is not water. It may be helpful for them to think about foods that have had the water removed, such as dried fruits and herbs.

10. Discuss Matter Change Question as it relates to BTB

Show slide 12 of the 3.1 Predictions and Planning about Radish Plants Growing PPT. Discuss with students how BTB can be used to measure matter change in a system. Highlight that the BTB in a closed container can be observed before and after a change happens in the system. Discuss the two possible conclusions students can draw from their observations:

- If the BTB changes from blue to yellow, then a chemical change may be producing CO_2
- If the BTB changes from yellow to blue, then a chemical change may be using CO_2 as a reactant.

11. Discuss students' ideas about plants in the light and dark.

Show slide 13 of the 3.1 Predictions and Planning about Radish Plants Growing PPT. Discuss with students their ideas about how light energy is related to matter change in plants.

- Consider with students how they might use BTB to determine the matter change that is occurring when plants are in the light and when plants are in the dark.

12. Have students complete their predictions for Ethanol Burning: Part B of the Predictions and Planning Tool.

Show slide 14 of the PPT. Have students find Part B on 3.1 Predictions and Planning about Radish Plants Growing PPT and ask them to record their ideas as individuals for both the matter movement and matter change questions.

Remind students that these are just *predictions*, and that there are no wrong answers at this point. Encourage them to write down all their ideas on the tool.

13. Have students discuss their predictions in pairs.

When students have completed Part B of their Predictions and Planning Tools, show slide 15 of the PPT. Divide students into pairs and tell them to compare and contrast their predictions with each other and to look for differences and similarities.

- Give students 2-3 minutes to compare their predictions. As students are sharing, circulate through the groups. Consider engaging students by: *Revoice what students said/wrote (for instance, I see/hear that you think the BTB will turn blue). Why do you think that? What do you two disagree about? Why do you disagree?*
- Pay attention to patterns in students' predictions as well as predictions that diverge from any of the patterns. Both will be valuable to discuss next as a whole class.

14. Have students plan the investigation: Part C of the Predictions and Planning Tool.

Show students Slide 16 of the PPT and describe the instruments and materials necessary for carrying out the investigation. Have students begin planning their investigation. There are two main variations in how much control students can have over this planning process

- Minimal student control: Discuss student ideas for how an investigation could be set up. Then have students follow the lab instructions for Activity 3.2.
- Maximal student control: Students in class develop their own consensus plans that will replace the lab instructions in Activity 3.2. (They may use the Investigation Planning Tool for making their plans. Note the importance of having different student groups following the same plan so that they can come to a consensus about patterns in data in Activity 3.2.)
- Some possible ideas of using lab materials are below:
  - Students might choose to add controls to the experiment, for example including both a Petri dish of yellow bromothymol blue (BTB) (made from blowing into the blue BTB with a straw) and a Petri dish of blue BTB to the chamber.
  - Students might also choose to set up a chamber with a Petri dish of blue BTB alone without the ethanol.

15. Save the Predictions and Planning Tools for later.

Display slide 17. Tell students that they will revisit their ideas after the investigation to see how their ideas changed over time.

Assessment

During the class, listen to the ideas that students offer in step 7 of the activity. Do students' predictions follow the rules? At this point, do not correct student ideas, but listen for what they say about matter and energy in the context of plant growth. After class, use the 3.1 Assessing the Predictions and Planning Tool for Plant Investigations to compare your students' work with what we would expect to see in Level 4 responses.

Ideally, the discussion about the Predictions and Planning Tool in this activity will reveal a range of student ideas. Some students will have Level 2 ideas with respect to the principles (matter and energy) and context-specific knowledge (how a plant grows). Listen to see if students have a sense of necessity about connecting mass changes and movement of atoms, and if they recognize that if the plant gains mass, then atoms must be moving into the plant. Also, listen to see if students account for energy separately from matter (Levels 3 and 4), or if they suggest

that some of the matter in the plants might be converted to energy (Levels 2 and 3). You do not need to correct any problems now; they will be addressed through the investigation and modeling in the activities to come.

Tips

- Have a designated place in the classroom where students store their **Expressing Ideas and Questions** and **Predictions and Planning Tools** so they can easily refer back to their ideas at the end of the lesson.
- Expect some students to make the right predictions for the wrong reasons. Note in particular whether they say that changes in the mass of the gel/paper towel indicate that atoms are moving.

Differentiation & Extending the Learning

Differentiation

- Refer back to *Systems & Scale* or *Animals* Predictions and Planning Tool as a model
- Strategic grouping with strong speakers
- Provide sentence stems for discussion and filling in the predictions tool.
- Read Three Questions Handout as a group by referring back to *Systems & Scale* or *Animals.*
- Allow students to use personal devices to watch the plants growing videos. Allow for slowdown and playback.
- Give examples of answers to the Three Questions and possibly post these as sentence stems for students.
- Keep student predictions in a safe place (notebook or class file).

Modifications

Document the thinking of the whole class on a large poster.

Extending the Learning

- Have students plan and carry out their own investigations to answer the Three Questions. If groups get unreliable data, you may want to carry out the investigations as planned in this unit, at least as a demonstration.
- Have students review their observations about plant growth that they have been collecting since the Pre-Lesson. Discuss what is similar, different, or surprising about this method of growing plants compared to more familiar methods.

Activity 3.2PT: Observing Plants' Mass Changes, Part 1 (30 min)

Overview and Preparation

Target Student Performance

Students harvest their radish plants and dry down the plants and the paper towel or gel in preparation for Activity 3.4.

Resources You Provide

- Containers of radish plants from the Pre-Lesson (1 per group)
- Digital scale (1 per group)
- Small paper bags or envelopes for drying plants (1 per container)
- Sunny windowsill or drying oven (domestic ovens work at low settings)
- Markers to label plants by student or group (1 per group)

Resources Provided

- 3.2PT Observing Plants' Mass Changes, Part 1 Worksheet (1 per student)
- 3.2PT Grading Observing Plants' Mass Changes, Part 1 Worksheet
- 3.2PT Observing Plants' Mass Changes, Part 1 PPT

Setup

Prepare your computer and projector for the 3.2PT Observing Plants' Mass Changes, Part 1 PPT. Print one copy per student of the 3.2PT Observing Plants' Mass Changes, Part 1 Worksheet.

Directions

1. Use the instructional model to show students where they are in the course of the unit.

Show slide 2 of the 3.2PT Observing Plants' Mass Changes, Part 1 PPT.

2. Have students count and harvest the plants.

Follow the instructions in Part A of the 3.2PT Observing Plants' Mass Changes, Part 1 Worksheet.

Show students slide 3 of the PPT and keep this up during the first part of the activity.

- Students should count and record the number of germinated plants vs. non-germinated seeds.
- Students should record the mass of their drying container (plants will stick when dry, so hard to separate) and label it.
- Guide students through carefully pulling their radish plants out from the wet paper towel. Try to get all the plant material (even roots and non-germinated seeds) in the envelopes or paper bags.

3. Dry the plants.

Follow the instructions in Part B of the 3.2PT Observing Plants' Mass Changes, Part 1 Worksheet.

- Labeled envelopes containing plants and the containers with the wet paper towel can be placed on a windowsill to dry out or can be dried overnight at the lowest temperature in a home oven. (<170 degrees) **IF YOU USE AN OVEN—**make sure that the material you place the plants on will not burn and start a fire! Windowsill plants will take a few days to dry if small but may take longer if they are large.

4. Have students record their observations

Record observations of the plants in Part C of 3.2PT Observing Plants' Mass Changes, Part 1 Worksheet.

- Show slide 4 of the PPT, which lists a few observation idea starters.

5. After drying the plants, continue with Activity 3.4.

Since it may take several days for the plants to dry, there are options for what to do with your students while waiting. You may move on to Activity 3.3 and conduct the Light and Dark Investigation. Or, if you started with Activity 3.3 first, you may move on to Lesson 4 which focuses on following up results from the Light and Dark Investigation (Activity 3.3) with explanations of photosynthesis and cellular respiration. Later, students will complete Evidence-Based Arguments Tool for this investigation (Activity 3.5) and explanations of biosynthesis in plants (Activities 5.1, 5.2, and 5.3). See the Plants Unit Front Matter for more information about this decision.

Assessment

Since this activity is primarily an opportunity for students to harvest their plants for Activity 3.4, there is little content in this activity to assess. You can use 3.2PT Grading Observing Plants' Mass Changes, Part 1 Worksheet to grade your students' work in collecting observations on 3.2PT Observing Plants' Mass Changes, Part 1 Worksheet

Differentiation & Extending the Learning

Differentiation

- Strategic grouping with strong speakers
- Compare class data orally and on the spreadsheet

Modifications

Extending the Learning

- Follow the same procedures to investigate other plants growing, such as peas.

Activity 3.2GL: Observing Plants' Mass Changes, Part 1 (30 min)

Overview and Preparation

Target Student Performance

Students harvest their radish plants and dry down the plants and the paper towel or gel in preparation for Activity 3.4.

Resources You Provide

- Tubes of radish plants from the Pre-Lesson (1 per student)
- Digital scale (1 per group)
- Small containers to collect gel from individual tubes to mass
- Small paper bags or envelopes for drying plants (1 per plant)
- Sunny windowsill or drying oven (domestic ovens work at low settings)
- Markers to label plants by student or group (1 per group)

Resources Provided

- 3.2GL Observing Plants' Mass Changes, Part 1 Worksheet (1 per student)
- 3.2GL Grading Observing Plants' Mass Changes, Part 1 Worksheet
- 3.2GL Observing Plants' Mass Changes, Part 1 PPT

Setup

- Each student or group of 4 students should have 1-2 tubes. For each group, provide a container to collect the gel that the students will extract from the plant roots. Unless you choose to dry out the gel, it will be discarded after the investigation.
- Provide a paper towel, small paper bags, or envelopes (1 per plant), on which to place the plants to dry.
- After the activity, students can assist with cleanup by rinsing out the plant test tubes.
- Prepare your computer and projector for the 3.2GL Observing Plants' Mass Changes, Part 1 PPT.
- Print one copy per student of the 3.2GL Observing Plants' Mass Changes, Part 1 Worksheet.

Directions

1. Use the instructional model to show students where they are in the course of the unit.

Show slide 2 of the 3.2GL Observing Plants' Mass Changes, Part 1 PPT.

2. Have students harvest the plants.

Follow the instructions in Part A of the 3.2GL Observing Plants' Mass Changes, Part 1 Worksheet.

- Show slide 3 and 4 of the PPT, which has the instructions and pictures of the process.
- You may want to demonstrate how to remove the gel from the roots to preserve as much of the plant as possible. Emphasize to students that they do not want to pull on the roots or they will break. Squeezing will generally not break roots.

- The worksheet prompts students to mass their hydrated gel after separating it from their plants and estimate the dry mass by using the percentage dry mass provided = 1.4%. Alternatively, you could dry the gel in an oven and use the scales to measure this directly.
- The worksheet also prompts students to mass the plant after harvesting. An estimated dry mass percentage of a radish seedling (7%) is provided. Students can use this value to estimate the dry mass present in their seedling. Make sure students save their initial measurements in a safe place as they will return to them in Activity 3.4.

3. Have students record their observations and estimate dry mass of gel and plants.

Record observations of the plants in Part B of 3.2GL Observing Plants' Mass Changes, Part 1 Worksheet.

- Show slide 5 of the PPT, which lists a few observation idea starters.

4. Dry the plants.

Students will be able to estimate the dry mass of their plants based on wet mass and compare this value to an actual dry mass they record.

- Plants individually labeled can be placed in a small paper bag or envelope on a windowsill to desiccate or can be dried overnight at the lowest temperature (<170 degrees F) in a home oven. **IF YOU USE AN OVEN—**make sure that the material you place the plants on will not burn and start a fire! Windowsill plants will take a few days to dry if small, but may take longer if they are large.
- Note: Radish plants contain only about 7% dry mass, so in order for most classroom scales to even record the dry mass of a single dried plant, the starting masses of the plants should be at least 0.75g. If your plants are smaller, either mass multiple plants together or use the 7% dry mass calculation to estimate dry mass from wet.

5. (Optional) Dry the gel.

Students may also want to desiccate their gel to see if the mass of the gel in their tubes changed over time and to see if they come up with a similar dry mass percentage (~1.4%).

- The gel desiccates best in an oven at low heat (~200 degrees or less) for at least 3 hours. Be aware that the desiccated gel will stick to any surface it is dried on, so students will have to mass the drying surface (non-flammable!) prior to placing the gel on it. Aluminum foil or parchment paper (labeled with the student name or a unique number) works well.

6. After drying the plants/gel, continue with Activity 3.4.

Since it may take several days for the plants to dry, there are options for what to do with your students while waiting. You may move on to Activity 3.3 and conduct the Light and Dark Investigation. Or, if you started with Activity 3.3 first, you may move on to Lesson 4 which focuses on following up results from the Light and Dark Investigation (Activity 3.3) with explanations of photosynthesis and cellular respiration. Later, students will complete Evidence-Based Arguments Tool for this investigation (Activity 3.5) and explanations of biosynthesis in plants (Activities 5.1, 5.2, and 5.3). See the Plants Unit Front Matter for more information about this decision.

Assessment

Since this activity is primarily an opportunity for students to harvest their plants for Activity 3.4, there is little content in this activity to assess. You can use 3.2GL Grading Observing Plants'

Mass Changes, Part 1 Worksheet to grade your students' work in collecting observations on 3.2GL Observing Plants' Mass Changes, Part 1 Worksheet.

Differentiation & Extending the Learning

Differentiation

- Strategic grouping with strong speakers
- Compare class data orally and on the spreadsheet

Modifications

Extending the Learning

- Follow the same procedures to investigate other plants growing, such as peas.

Activity 3.3: Observing Plants in the Light and Dark (60 min over 2 days)

Overview and Preparation

Target Student Performance

Students observe how plants affect BTB in the light and dark, identify patterns in data, and reach consensus with other groups about their results.

Resources You Provide

- Radish plants (either in tubes (GL) or containers (PT) from the Pre-Lesson. Note: 3-4 tubes or 1-2 containers will be plenty for each experiment replicate.
- Dark box, thick black trash bag, or very dark closet (1 per class)
- Fluorescent grow light or sunny windowsill (1 per class)
- Label (1 per group student group)
- Petri dish with blue BTB (1 per container/student group)
- Petri dish with yellow BTB (1 per container/student group)
- Sealable 6.8 liter (or 29 cup) container (1 per group)
- (From previous lesson) 3.1 Predictions and Planning Tool for Plant Investigations with student answers

Resources Provided

- 3.3 Observing Plants in the Light and Dark Worksheet (1 per student)
- 3.3 Grading the Observing Plants in the Light and Dark Worksheet
- 3.3 Observing Plants in the Light and Dark PPT
- 3.3 Plants in the Light and Dark Class Results 11 x 17 Poster (1 per class)
- *Carbon TIME* Growing Plants Video
- (Optional) 3.5 Evidence-Based Arguments Tool for Plants

Recurring Resources

- (Optional) BTB Color Handout (1 per group)

Setup

Assign each group of students a treatment (light or dark). For each group, select growing radishes (3-4 GL tubes or 1-2 PT containers) that were planted in the *Plants Unit* Pre-Lesson. For each group, provide 1 sealable 6.8-liter (29 cup) container, one Petri dish of blue BTB, one Petri dish of yellow BTB, and a label. Prepare enough space under a grow light or in a sunny windowsill for the “plants in the light” containers, and enough room in a dark closet for the “plants in the dark” containers. Optionally, print a few BTB Color Handouts for the students to use as a color reference.

- Refer to the BTB Information and Instructions Handout for information about preparing BTB.
- Prepare your computer and projector for the 3.3 Observing Plants in the Light and Dark PPT.
- Print one copy per student of the 3.3 Observing Plants in the Light and Dark Worksheet.
- Print one copy of the 3.3 Plants in the Light and Dark Class Results 11 x 17 Poster.

Directions

1. Use the instructional model to show students where they are in the course of the unit.

Show slide 2 of the 3.3 Observing Plants in the Light and Dark PPT.

2. (Day 1) Have students prepare for the plants in the light and dark investigation.

Follow the instructions in Part A of the 3.3 Observing Plants in the Light and Dark Worksheet.

- Slide 3 of the 3.3 Observing Plants in the Light and Dark PPT has pictures of the setup for the investigation.
- Let students re-watch the first three minutes of the *Carbon TIME* Growing Plants Video. This part discusses the questions and shows the setup for the investigation.
- If you have multiple classes, each class can set up one or two 6.8-liter sealable plastic containers in the light and one or two 6.8-liter sealable plastic containers in the dark. Note: large sealable containers with room for the BTB and plants will do; the container does not need to be this exact size.
- If you have a single class, then each group of four students can set up one 6.8-liter sealable plastic container, with half the 6.8-liter sealable plastic containers going into the light and half going into the dark.

3. (Day 1) Leave the containers overnight.

Leave the lights on for the 6.8-liter sealable plastic containers in the light.

4. (Day 2) Have students observe and record results.

Each student should be responsible for observing one 6.8-liter sealable plastic container in the light and one 6.8-liter sealable plastic container in the dark and recording their observations in Part B of the 3.3 Observing Plants in the Light and Dark Worksheet.

Show slide 4 to allow students to see the possible colors of BTB.

Record results for all the containers on the 3.3 Observing Plants in the Light and Dark Class Results 11 x 17 Poster.

5. Have students compare data between groups and look for patterns.

Show slide 5. Discuss the general patterns the class sees for all the containers, and have students record summaries of those patterns in Part C of the 3.3 Observing Plants in the Light and Dark Worksheet. (In the light, yellow BTB turns blue. In the dark, blue BTB turns yellow.)

- Show the second part of the *Carbon TIME* Growing Plants Video, after the first intermission where Darryl and Nina discuss the results of the Plants in the Light and Dark Investigation (begin at about 2:30).
- Ask the class to compare their results to Darryl and Nina's results, pausing the video when the data are shown. Ask students if they see the same patterns, any similarities and/or differences. Ask them why there may be similarities and/or differences.
- If your students' plants in the light dark investigation fails to provide the expected BTB color changes (which could happen for a variety of reasons, including too much NaOH in the BTB or too high concentration of BTB), use the *Carbon TIME* Growing Plants Video to help them compare their results with the desired results. Use this as a starting point for a conversation and ask the students why the results are different.

6. Revisit predictions from the previous activity.

Show slide 6. Ask students to retrieve their completed tools from the previous activity: 3.1 Predictions and Planning Tool for Plant Investigations. Have them compare the predictions they made with the results of the investigation. Which predictions were correct? Which predictions were incorrect? What questions do they still need to answer?

Remind students that food is necessary for plants to be able to grow and move. Tell students that they will use the data that they collected here to help them to be able to explain two processes that relate to plants growing: photosynthesis and cellular respiration.

7. (Optional) Partially complete the Evidence-Based Arguments Tool.

If you plan on teaching Lesson 4 while waiting for students' radish plants to dry (see the Plants Unit Front Matter file for more information on making this choice), be sure to have students partially complete the 3.5 Evidence-Based Arguments Tool for Plants first. See Activity 3.5 for more guidance on completing this step.

8. Have students complete an exit ticket.

Show slide 7 of the 3.3 Observing Plants in the Light and Dark PPT.

- Conclusions: What did you observe during the investigation?
- Predictions: What do you think happened to the CO_2 that the plants absorbed in the light?
- On a sheet of paper or a sticky note, have students individually answer the exit ticket questions. Depending on time, you may have students answer both questions, assign students to answer a particular question, or let students choose one question to answer. Collect and review the answers.
- The conclusions question will provide you with information about what your students are taking away from the activity. Student answers to the conclusions question can be used on the Driving Question Board (if you are using one). The predictions question allows students to begin thinking about the next activity and allows you to assess their current ideas as you prepare for the next activity. Student answers to the predictions question can be used as a lead into the next activity.

Assessment

- Use the class discussion to interpret how successful your students are at identifying patterns in the class data. Use the 3.3 Grading the Observing Plants in the Light and Dark Worksheet to determine if your students had any trouble with data collection.
- During this activity, note students' success in observing changes in BTB. Also note students' ability to reach a consensus about patterns in data and how they interpret results.
- The discussion in step 5 can be helpful for informal assessment in two ways: 1) it can help you assess your students' skills in identifying sources of error and finding patterns in data, and 2) it can help you assess how well students identify the limits of the evidence. Do they recognize that the investigation does not fully answer the Three Questions?

Tips

- Discuss threats to accuracy of measurement.
- Check to see if students can identify unanswered questions from the investigation.

Differentiation & Extending the Learning

Differentiation

- Strategic grouping with strong speakers

- Have students explain aloud the observation plan after reading it
- Compare class data orally and on the spreadsheet

Modifications

- Conduct the investigation as a demonstration if you are short on time or resources.
- Parts 1 and 2 of the *Carbon TIME* Growing Plants Video show the investigation and patterns of results. While we do not recommend this, if time is not available, students can watch the video instead of doing the investigation.
- Have students develop the investigation design on their own using the tools provided. For example, students may choose to set up a control treatment as a container with BTB and no plants.
- Put the “plants in the dark” container inside an opaque plastic bag instead of in a dark closet.

Extending the Learning

- Have students compare photosynthesis rates between plants in the sun and plants under a grow light.

Activity 3.4PT: Observing Plants' Mass Changes, Part 2 (45 min)

Overview and Preparation

Target Student Performance

Students measure the dry weight of harvested plants and of paper towels or gel, identify patterns in data, and reach consensus with other groups about their results.

Resources You Provide

- Students' dry radish plants (1 envelope or bag per group)
- Digital balance (1 per group)
- (From previous lesson) Pre-Lesson 0.2PT Plant Growth Investigation Setup Worksheet
- (From previous lesson) 3.1PT Predictions and Planning Tool for Plant Investigations
- (From previous lesson) 3.2PT Observing Plants' Mass Changes, Part 1 Worksheet

Resources Provided

- 3.4PT Observing Plants' Mass Changes, Part 2 PPT
- 3.4PT Observing Plants' Mass Changes Class Results 11 x 17 Poster (1 per class)
- 3.4PT Observing Plants' Mass Changes, Part 2 Worksheet (1 per student)
- 3.4PT Grading the Observing Plants' Mass Changes, Part 2 Worksheet

Setup

By the time you are completing this Activity, your plants and paper towel should be completely dried out.

Print the 3.4PT Observing Plants' Mass Changes Class Results 11 x 17 Poster before class. Your students will also need their copies of the worksheets they completed in Pre-Activity 0.2PT, Activity 3.1PT, and Activity 3.2PT. Print one copy of 3.4PT Observing Plants' Mass Changes, Part 2 Worksheet for each student. Prepare a computer with a projector to display the PPT.

Directions

1. Use the instructional model to show students where they are in the course of the unit.

Show slide 2 of the 3.4PT Observing Plants' Mass Changes, Part 2 PPT.

2. Mass the dry plants

Remind students about when they harvested their radish plants in Activity 3.2.

- Assure that students have their completed worksheets in front of them from Pre 0.2PT and 3.2PT.
- Pass out the worksheet for today.
- Have students follow part B of the worksheet to record their mass data.
- Remind students to subtract the mass of the empty envelope (or bag) in Part B.

3. Compile data

Following the directions in Part C on the students' worksheet, have students fill in the data table, showing slide 3 of the 3.4PT Observing Plants' Mass Changes, Part 2 PPT.

- Have students record their data on their worksheets and follow the rest of the instructions on the worksheet to fill in their data table.

4. Have students compare data between groups and look for patterns.

Have students select a recorder to input their group's results on the 3.4 Observing Plants' Mass Changes Class Results 11 x 17 Poster. Lead a discussion to help students compare results across groups and identify patterns in the data.

- Use Slide 4 of the PPT to guide students through data recording.
- Have students compare the dry mass change of the plant with the dry mass change of the paper towel.
- Show students slide 5 of the PPT. Have students discuss whether the patterns they observe in the class data match with their predictions.
- Discuss any outliers or unexplained data points.

5. Have students compare their class's data with data from another class to identify patterns.

Show students slide 6 from the PPT and ask them to compare their results to Ms. A's class results.

- Ask students if they recognize similar patterns from their own data. Use the poster to compare. What similarities or differences do they notice? What patterns do they see?
- Probe student thinking with questions such as, *Where did this mass come from? Did the mass come from the paper towel? What evidence do we have to build our conclusions?*
- Use slide 7 to discuss the idea that they know from this investigation that the majority of the mass of the plant did not come from the paper towel, so the mass must come either from air or from water. An unknown question is, does water or air make up the mass of the dried plants? Students may have some ideas about where this mass came from. Tell students that you will discuss where this mass came from later in this Lesson.

6. Have students complete Part D of their worksheet.

Use slide 8 and Part D of the worksheet to help students describe the patterns they observed during the observation.

- Help students to recognize that the mass changes provide them with evidence that much of the plant's mass is coming from a source other than the medium in which it is growing. However, this evidence does not show where this mass is coming from.

7. Revisit predictions from earlier.

Ask students to retrieve their completed tools from the 3.1PT Predictions and Planning Tool for Plant Investigations. Have them compare the predictions they made with the results of the investigation. Which predictions were correct? Which predictions were incorrect? What questions do they still need to answer?

- Tell students that they will use the data that they collected here to help them to be able to answer the Matter Movement Question.

8. Have students complete an exit ticket.

Show slide 9 of the 3.4PT Observing Plants' Mass Changes, Part 2 PPT.

- Conclusions: What did you observe during the investigation?
- Predictions: How do you think the plants gained more mass than the paper towel lost?
- On a sheet of paper or a sticky note, have students individually answer the exit ticket questions. Depending on time, you may have students answer both questions, assign students to answer a particular question, or let students choose one question to answer. Collect and review the answers.
- The conclusions question will provide you with information about what your students are taking away from the activity. Student answers to the conclusions question can be used on the Driving Question Board (if you are using one). The predictions question allows students to begin thinking about the next activity and allows you to assess their current ideas as you prepare for the next activity. Student answers to the predictions question can be used as a lead into the next activity.

Assessment

- Use the class discussion to interpret how successful your students are at identifying patterns in the class data. Use the 3.4PT Grading the Observing Plants' Mass Changes, Part 2 Worksheet to determine if your students had any trouble with data collection.
- During this activity, note students' success in measuring changes in mass. Also note students' ability to reach a consensus about patterns in data and how they interpret results.
- The discussions in steps 4 and 5 can be helpful for informal assessment in two ways: 1) It can help you assess your students' skills in identifying sources of error and finding patterns in data, and 2) it can help you assess how well students identify the limits of the evidence. Do they recognize that the investigation does not fully answer the Matter Change Question?

Tips

- Be sure to collect results from the different groups and compare their measurements. Discuss threats to accuracy of measurement.
- Check to see if students can identify unanswered questions from the investigation.

Differentiation & Extending the Learning

Differentiation

- Strategic grouping with strong speakers
- Compare class data orally and on the spreadsheet
- Think-Pair-Share about the class data in comparison to another class' data

Modifications

Extending the Learning

- Have students make predictions and design investigations to see how the results of the investigation would change if they used different types of plants.

Activity 3.4GL: Observing Plants' Mass Changes, Part 2 (45 min)

Overview and Preparation

Target Student Performance

Students measure the dry weight of harvested plants and of paper towels or gel, identify patterns in data, and reach consensus with other groups about their results.

Resources You Provide

- Students' dry radish plants (1 per student)
- Digital balance (1 per group of four students)
- Empty container (for measuring the mass of dried plant and optional dried gel) (1 per group of four students)
- (From previous lesson) Pre-Lesson 0.2GL Plant Growth Investigation Setup Worksheet
- (From previous lesson) 3.1GL Predictions and Planning Tool for Plant Investigations
- (From previous lesson) 3.2GL Observing Plants' Mass Changes, Part 1 Worksheet

Resources Provided

- 3.4GL Observing Plants' Mass Changes, Part 2 PPT
- 3.4GL Observing Plants' Mass Changes Class Results 11 x 17 Poster (1 per class)
- 3.4GL Observing Plants' Mass Changes, Part 2 Worksheet (1 per student)
- 3.4GL Grading the Observing Plants' Mass Changes, Part 2 Worksheet

Setup

By the time you are completing this Activity, your plants and gel (optional) should be completely dried out. Prepare an empty container for each group on which students can measure their masses.

Print the 3.4GL Observing Plants' Mass Changes Class Results 11 x 17 Poster before class. Your students will also need their copies of the worksheets they completed in Pre-Activity 0.2GL, Activity 3.1GL, and Activity 3.2GL. Print one copy of 3.4GL Observing Plants' Mass Changes, Part 2 Worksheet for each student. Prepare a computer with a projector to display the PPT.

Directions

1. Use the instructional model to show students where they are in the course of the unit.

Show slide 2 of the 3.4GL Observing Plants' Mass Changes, Part 2 PPT.

2. Mass the dry plants

Remind students about when they harvested their radish plants in Lesson 3.2.

- Assure that students have their completed worksheets in front of them from Pre 0.2GL and 3.2.
- Pass out the worksheet for today.
- Show slide 3 of the 3.4GL Observing Plants' Mass Changes, Part 2 PPT.
- Remind students to tare their scales with their containers before measuring the dry mass of their radish plants (and optional dried gel).

- Note: If hydrated plants were less than 0.75 grams, the dried plants (only 7% mass remaining) may not register on the scale. Options for this scenario. 1) Use the student estimates of the dry plant mass (7%) in the table and continue, or 2) Have students collectively mass their plants in groups, and modify their tables to account for mass changes in their 4 plants (remembering to sum the 4 seed masses, 4 hydrated/desiccated gel masses, etc.)

- Have students record their data on their worksheets and follow the rest of the instructions on the worksheet to fill in their data table.
- Remember that the radish seeds and the solids in the Ionic Grow mixture have tiny masses—less than 0.01 grams. Students should have recorded these masses as "<0.01g." When doing calculations in this activity with this number, they should treat it as a zero.
- Encourage students to compare their actual dry mass with the estimated dry mass they calculated in Activity 3.2.

3. Have students compare data between groups and look for patterns.

Have students select a recorder to input their group's results on the 3.4GL Observing Plants' Mass Changes Class Results 11 x 17 Poster. Lead a discussion to help students compare results across groups and identify patterns in the data.

- Use Slide 4 of the PPT to guide students through data recording.
- Have students compare the dry mass change of the plant with the dry mass change of the gel.
- Show students slide 5 of the PPT. Have students discuss whether the patterns they observe in the class data match with their predictions.
- Discuss any outliers or unexplained data points.

4. Have students compare their class's data with data from another class to identify patterns.

Show students slide 6 from the PPT and ask them to compare their results to Ms. Hoyt's class results (displayed as data from individual plants).

- Ask students if they recognize similar patterns from their own data. Use the poster to compare. What similarities or differences do they notice? What patterns do they see?
- Probe student thinking with questions such as, *Where did this mass come from? Did the mass come from the gel? What evidence do we have to build our conclusions?*
- Use slide 7 to discuss the idea that they know from this investigation that the majority of the mass of the plant did not come from the gel, so the mass must come either from air or from water. An unknown question is, does water or air make up the mass of the dried plants? Students may have some ideas about where this mass came from. Tell students that you will discuss where this mass came from later in this lesson.

5. Have students complete Part D of their worksheet.

Use slide 8 and Part D of the worksheet to help students describe the patterns they observed during the observation.

- Help students to recognize that the mass changes provide them with evidence that much of the plant's mass is coming from a source other than the medium in which it is growing. However, this evidence does not show where this mass is coming from.

6. Revisit predictions from earlier.

Ask students to retrieve their completed 3.1 Predictions and Planning Tool for Plant Investigations. Have them compare the predictions they made with the results of the

investigation. Which predictions were supported by their results? Which predictions were not supported by their results? What questions do they still need to answer?

- Tell students that they will use the data that they collected here to help them to be able to answer the Matter Movement Question.

7. Have students complete an exit ticket.

Show slide 9 of the 3.4GL Observing Plants' Mass Changes, Part 2 PPT.

- Conclusions: What did you observe during the investigation?
- Predictions: How do you think the plants gained more mass than the gel lost?
- On a sheet of paper or a sticky note, have students individually answer the exit ticket questions. Depending on time, you may have students answer both questions, assign students to answer a particular question, or let students choose one question to answer. Collect and review the answers.
- The conclusions question will provide you with information about what your students are taking away from the activity. Student answers to the conclusions question can be used on the Driving Question Board (if you are using one). The predictions question allows students to begin thinking about the next activity and allows you to assess their current ideas as you prepare for the next activity. Student answers to the predictions question can be used as a lead into the next activity.

Assessment

- Use the class discussion to interpret how successful your students are at identifying patterns in the class data. Use the 3.4GL Grading the Observing Plants' Mass Changes, Part 2 Worksheet to determine if your students had any trouble with data collection.
- During this activity, note students' success in measuring changes in mass. Also note students' ability to reach a consensus about patterns in data and how they interpret results.
- The discussions in steps 3 and 4 can be helpful for informal assessment in two ways: 1) It can help you assess your students' skills in identifying sources of error and finding patterns in data, and 2) it can help you assess how well students identify the limits of the evidence. Do they recognize that the investigation does not fully answer the Matter Change Question?

Tips

- Be sure to collect results from the different groups and compare their measurements. Discuss threats to accuracy of measurement.
- Check to see if students can identify unanswered questions from the investigation.

Differentiation & Extending the Learning

Differentiation

- Strategic grouping with strong speakers
- Compare class data orally and on the spreadsheet
- Think-Pair-Share about the class data in comparison to another class' data

Modifications

Extending the Learning

- Have students make predictions and design investigations to see how the results of the investigation would change if they used different types of plants.

Activity 3.5: Evidence-Based Arguments about Plants (50 min)

Overview and Preparation

Target Student Performance

Students (a) use data from their investigations to develop evidence-based arguments about how matter moves and changes and how energy changes when plants grow, move, and function; and (b) identify unanswered questions about matter movement and matter change that the data are insufficient to address.

Resources You Provide

- (From previous lesson) 3.3 Plants in the Light and Dark Class Results 11 x 17 Poster
- (From previous lesson) 3.3 Observing Plants in the Light and Dark Worksheet
- (From previous lesson) 3.4 Plants' Mass Changes Class Results 11 x 17 Poster
- (From previous lesson) 3.4 Observing Plants Mass Changes, Part 2 Worksheet (GL or PT)

Resources Provided

- 3.5 Evidence-Based Arguments Tool for Plants (1 per student)
- 3.5 Assessing the Evidence-Based Arguments Tool for Plants
- 3.5 Evidence-Based Arguments Tool for Plants PPT
- *Carbon TIME* Growing Plants Video

Recurring Resources

- Three Questions Handout (1 per student)
- Learning Tracking Tool for Plants (1 per student)
- Assessing the Learning Tracking Tool for Plants

Setup

Print one copy of 3.5 Evidence-Based Arguments Tool for Plants for each student. Make sure that the 3.3 Plants in the Light and Dark Class Results and 3.4 Plants' Mass Changes Class Results 11 x 17 Posters from the previous activities are available. Prepare your computer and projector for the 3.5 Evidence-Based Arguments Tool for Plants PPT. Set up computer, speakers, and projector for students to view the *Carbon TIME* Growing Plants Video.

Directions

1. Use the instructional model to show students where they are in the course of the unit.

Show slide 2 of the 3.5 Evidence-Based Arguments Tool for Plants PPT.

2. Review both plant investigations in the video.

Show slide 3 of the 3.5 Evidence-Based Arguments Tool for Plants PPT. Show students the final section, beginning around 6:20, of the *Carbon TIME* Growing Plants Video to review both plant investigations with students.

- This video was produced when the *Carbon TIME Plants Unit* used vermiculite instead of plant gel. You may need to help students make connections between the data presented in the video with the vermiculite and the data students investigated with the plant gel or paper towel.

3. Have students review their results from the investigation.

Display slide 4 of the 3.5 Evidence-Based Arguments Tool for Plants PPT. Draw students' attention to the Class Results 11 x 17 Posters from the investigations (3.3 & 3.4) and students' own Observing Plants Worksheets (from 3.2 & 3.4), section D, "Results for the whole class." Ask the students to find a partner, and in their own words, review what happened during the investigations. Tell them to discuss:

- What patterns they observed in the mass change
- What patterns they observed in the BTB color change

Tell students that when scientists construct arguments for what happened, using evidence from observations is important, so today's activity is designed to help them use the evidence from the investigation to construct an argument for "what happens when plants are in the light and dark" and "what happens when plants grow" come to class consensus.

4. Have students develop arguments for what happened as individuals.

Display slide 5 of the 3.5 Evidence-Based Arguments Tool for Plants PPT. Pass out one copy of 3.5 Evidence-Based Arguments Tool for Plants to each student. Review Tool directions. Also, have students take out their Three Questions Handout and be ready to refer to their class results.

- Instruct students to complete their evidence, conclusions, and unanswered questions as individuals for the Three Questions.
- Give students about 5-10 minutes to complete the process tool.

5. Have students compare and revise arguments in pairs.

Display slide 6 of the 3.5 Evidence-Based Arguments Tool for Plants PPT. Divide students into pairs.

- Have each pair compare their **evidence, conclusions,** and **unanswered questions** for the Matter Movement Question.
- Have partners discuss how their ideas are alike and different. Have students change or add to their responses, based on partner input.
- Have students repeat this step for the Matter Change Question and the Energy Question.
- As students are sharing, circulate through the groups. Consider asking questions such as, *How does this (refer to students' evidence and/or conclusions) help us better understand the Matter Movement Question (or substitute one of the other Three Questions)? What questions do you still have at the atomic-molecular level to better understand this phenomenon?*
- Pay attention to patterns in students' ideas. You will want to begin moving towards class consensus in this activity.
- Partner work should take about 10 minutes.

6. Have a class discussion of the Matter Movement Question; move toward class consensus.

Display slide 7 of the 3.5 Evidence-Based Arguments Tool for Plants PPT.

- Have students/pairs share their evidence and conclusions for the Matter Movement question. Keep a class record, using the PPT slides or board. Ask students to update their answers by using a different colored writing utensil. Discussions should move toward class consensus. Use class conversation to correct student ideas. Use the Three Questions Handout to help guide towards consensus by following the established rules.

- Have students share unanswered questions. Discussions should move toward class consensus. Use the 3.5 Assessing the Evidence-Based Arguments Tool for Plants to guide your goals for consensus. Note that students may contribute unanswered questions that align with rules on the Three Questions Handout, but may not closely align with those on the Assessing worksheet. You may still choose to record those unanswered questions. These may be answered in other parts of this unit or even in other units during the school year. However, at this point in this unit, though there may be several viable paths of inquiry moving forward, you will begin to more closely guide the path of inquiry in one direction – in this case towards molecular modeling of photosynthesis.
- Class discussion should take about 10 minutes.

7. Repeat step 6 with the Matter Change Question; move toward class consensus.

Display slide 8 of the 3.5 Evidence-Based Arguments Tool for Plants PPT.

- Class discussion may take another 10 minutes.

8. Repeat step 6 with the Energy Change Question; move toward class consensus.

Display slide 9 of the 3.5 Evidence-Based Arguments Tool for Plants PPT.

- Class discussion may take another 10 minutes.

9. Discuss how the Unanswered Questions shape our next steps, and the transition from inquiry to application.

Display slide 10 of the 3.5 Evidence-Based Arguments Tool for Plants PPT.

- Use the Unanswered Questions to set the stage for students' next steps, specifically the need to know what's happening at the atomic-molecular scale.
- Take a moment to show students that you have arrived at the "top of the triangle" on the instructional model poster. This means they will be making a transition. When they went "up the triangle," they conducted an investigation and collected evidence based on what they could observe using their own eyes and also tools (e.g., macroscopic observations). Now they are preparing to go "down the triangle," when they will figure out how to explain what happened in the investigations at an atomic-molecular scale by being provided and practicing with a model for scientifically-accurate thinking.

10. Save the Evidence-Based Arguments Tools for later.

Display slide 11. Tell students that they will revisit their unanswered questions later in the unit to see which questions they can now answer. Save the PPT slides with the class's unanswered questions and/or take a picture of them for later.

11. Have students complete an exit ticket.

Show slide 12 of the 3.5 Evidence-Based Arguments Tool for Plants PPT.

- Conclusions: What is our conclusion for the matter movement question from the investigation?
- Predictions: What other questions do you have about how plants grow?
- On a sheet of paper or a sticky note, have students individually answer the exit ticket questions. Depending on time, you may have students answer both questions, assign students to answer a particular question, or let students choose one question to answer. Collect and review the answers.
- The conclusions question will provide you with information about what your students are taking away from the activity. Student answers to the conclusions question can be used

on the Driving Question Board (if you are using one). The predictions question allows students to begin thinking about the next activity and allows you to assess their current ideas as you prepare for the next activity. Student answers to the predictions question can be used as a lead into the next activity.

12. Have a discussion to complete the Learning Tracking Tool for this activity chunk.

Show slide 13 of the 3.5 Evidence-Based Arguments Tool for Plants PPT.

- Pass out a Learning Tracking Tool for Plants to each student.
- Have students write the activity chunk name in the first column, "Investigating Plants" and their role, "Investigator."
- Have a class discussion about what students did during the activity chunk. When you come to consensus as a class, have students record the answer in the second column of the tool.
- Have a class discussion about what students figured out during the activity chunk that will help them in answering the unit driving question. When you come to consensus as a class, have students record the answer in the third column of the tool.
- Have a class discussion about what students are wondering now that will help them move towards answering the unit driving question. Have students record the questions in the fourth column of the tool.
- Have students keep their Learning Tracking Tool for future activities.
- Example Learning Tracking Tool

Activity Chunk	What Did We Do?	What Did We Figure Out?	What Are We Asking Now?
Investigating Plants Investigator	Conduct investigations to explore what happens when plants grow and when plants are left in the light and in the dark. Use the Predictions and Planning Tool and the Evidence-Based Arguments Tool.	The mass of the plant increased while the mass of the paper towel (or gel) remained the same. In the dark, CO_2 leaves the plant and enters the air. In the light, CO_2 leaves the air and moves into the plant.	How do plants get food and energy?

Assessment

During the class discussion, listen for students making connections to the investigation and their arguments. Are they drawing on observations from the investigation or from other sources of knowledge and experience? Use the 3.5 Assessing the Evidence-Based Arguments Tool for Plants to assess your students' thinking at this point in the unit. At this point, they have concluded their "up the triangle" journey, and in Lessons 4-5 they will head "down the triangle" for the application sequence.

Tips

Have the students store their 3.5 Evidence-Based Arguments Tool for Plants in the same place as their Expressing Ideas and Questions and Predictions and Planning Tools so they can be easily revisited.

Differentiation & Extending the Learning

Differentiation

- Strategic grouping with strong speakers
- Provide sentence stems for discussion and filling in the Evidence-Based Arguments Tool
- Refer to previous Evidence-Based Arguments Tools from *Systems and Scale* or *Animals*, if applicable
- Compare the Evidence-Based Arguments Tool to the Predictions and Planning Tool. Have students verbalize similarities and differences in groups before sharing with the class.

Modifications

Extending the Learning