Pre-Lesson 1: Investigation Setup

Tab 1: Overview

Students set up an investigation in preparation for the *Plants Unit*. Plants will be ready to harvest two to four weeks later.

Download PDF of Pre-Lesson 1 Teacher's Guide

Guiding Question

How does a plant gain mass?

Activities in this Lesson

Note: There are two different pathways to choose from in the Pre-Lesson. Please see the Plants Unit Front Matter document, the Student Challenges and Teacher Choices in the Plants Unit document, and/or the Background Information section below for clarification in making this instructional decision.

Gel Protocol (2-turtle)

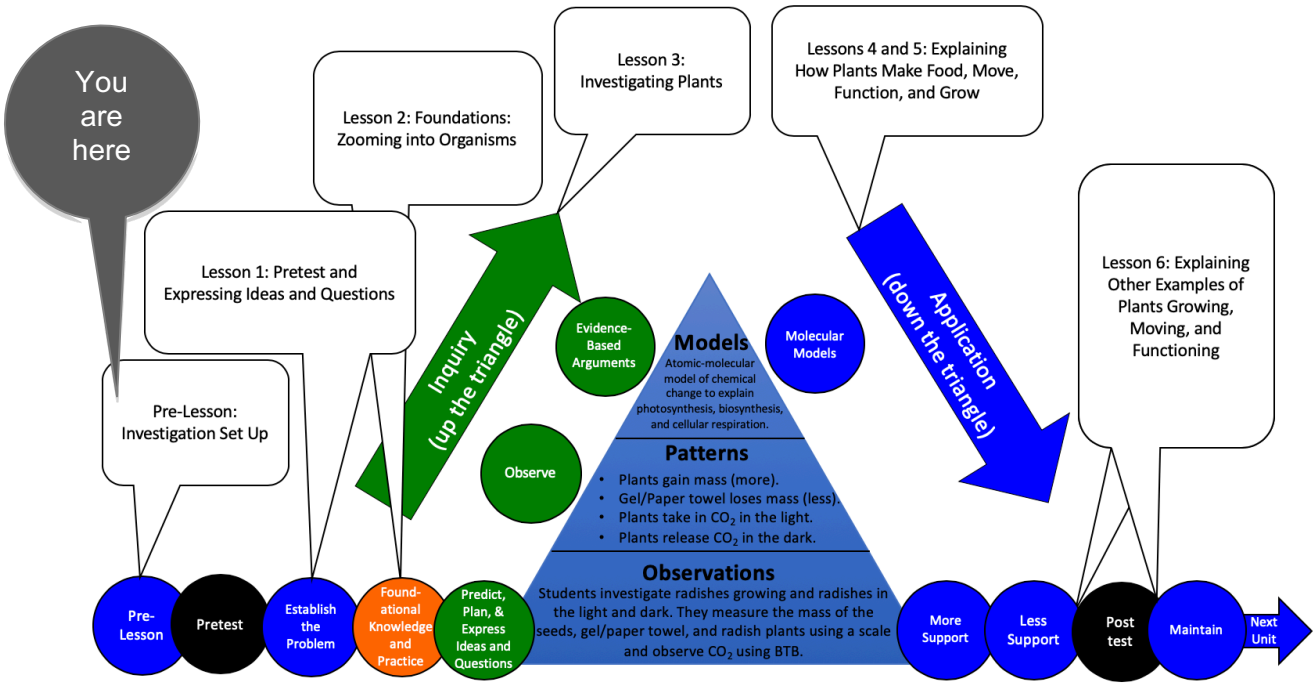
- Pre-Activity 0.1GL: Keeping Track of Water in Solids and Liquids (60 min + overnight or several days)
- Pre-Activity 0.2GL: Plant Growth Investigation Setup (45-60 min over one or two days)

Paper Towel Protocol (1-turtle)

- Pre-Activity 0.2PT: Plant Growth Investigation Setup (45-60 min)

Unit Map

The *Plants* Unit



Tab 2: Learning Goals

Target Performances

Activity	*Target Performance*
Pre-Lesson 1: Investigation Setup	
Pre-Activity 0.2GL: Keeping Track of Solids in Mixtures	Students will distinguish between solid mass (or dry mass) and total mass of materials consisting of water mixed with solid materials and use measurement techniques to determine the mass of solids in the mixtures.
Pre-Activity 0.2GL: Plant Growth Investigation Setup	Students will make initial measurements of the dry mass of radish seeds and growth media and start plants growing.
Pre-Activity 0.2PT: Plant Growth Investigation Setup	Students will make initial measurements of the dry mass of radish seeds and growth media and start plants growing.

NGSS Performance Expectations

Middle school

- MS. Matter and Energy in Organisms and Ecosystems. MS-LS1-6. Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.

High school

- HS. Chemical Reactions. HS-PS1-7. Use mathematical representations to support that claim that atoms, and therefore mass, are conserved during a chemical reaction.

Tab 3: Background Information

Three-dimensional Learning Progression (accordion)

The plants that are set up in the Gel Protocol (2-turtle) Pre-Lesson need about **four weeks** to grow to a point where they have gained enough mass to produce significant results in Lesson 3. The Paper Towel Protocol (1-turtle) may take as few as **2 weeks** to achieve significant mass gain results. *Thus, the Pre-Lesson(s) should be conducted one to three weeks before you plan to begin Lesson 1 of the Plants Unit, depending on which pathway you choose.*

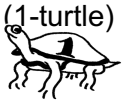
Students may begin this Unit thinking that plants build the majority of their mass from minerals and nutrients in the soil. Although atoms from soil minerals and water contribute trace amounts of materials during biosynthesis (e.g., nitrogen, potassium, and phosphorous from the soil), the majority of biomass is built from carbon from CO_2 in the air. By growing plants from seeds and taking measurements of plant dry mass and the dry mass of the rest of the system, this investigation gives students evidence that plants do not build their mass from the growing medium or water. Lesson 4 (Photosynthesis & Cellular Respiration) and especially Lesson 5 (Biosynthesis) give students further evidence that plants build their mass from materials they get from the air.

This Pre-Lesson, then, sets up for students not only the actual growing of the plants, but it also introduces to students some foundational knowledge about the importance of measuring a plant's dry mass. Students will take some initial measurements of the plant systems they are setting up as a reference for use in Lesson 3. In preparation for the investigations in Lesson 3,

keep in mind that inevitably things go wrong when growing plants, so make sure to plant some extra radishes (we recommend one extra per group of students). Additionally, you may want to have some extra growing plants in the classroom or at home that are available to potentially do the Plants in the Light and Dark investigation (Activity 3.3). If you decide to have students harvest their radish plants first (in Activity 3.2), they will not have their own radish plants available for Activity 3.3. Therefore, they will either need to rely on the extras that you plant in this Pre-Lesson, or on other growing plants that are available in the classroom or that are brought in from home.

There are two pathways from which to choose when implementing this Pre-Lesson, which will then extend into Lesson 5. The storyline supporting each pathway is the same: students will discover that their radish plants end up with more dry mass in them than they introduced into the system. Where did that mass come from? In Lesson 5, the task for students will be to explain where this mass came from. In this Pre-Lesson, each pathway will help students establish a foundation on which to understand that the mass didn't come from the materials they put into the system. Each pathway will also utilize a text and/or a video to help establish this problem for students. However, each pathway will engage students in different levels of measurements and calculations in order to meet this same goal.

You may choose a pathway based on the amount of instructional time you have to teach the unit, the complexity of measurements and calculations your students can handle while still understanding the underlying concept, or the learning goals you have for your students in this unit. Please refer to the following table for a brief outline of each pathway in the Pre-Lesson.

Pathway	Activities to Complete	Engagement	Estimated Time
Gel Protocol (2 turtle) 	Pre-Activity 0.1GL & Pre-Activity 0.2GL	Students will find the percentage of dry mass in various mixtures, including the gel and nutrient solution used in this setup. They will use these percentages to calculate the dry mass of their own materials. Students grow individual radish plants in test tubes.	60 min + overnight or several days & 45 min
Paper towel Protocol (1-turtle) 	Pre-Activity 0.2PT	The teacher will guide students through taking group measurements of the dry mass of each material (seeds and paper towel) in the system. Groups of students grow multiple (~20) radishes in small aluminum tins and brown paper towel.	45 – 60 min.

The following table is excerpted from the Plants Unit Front Matter document and is also in the Student Challenges and Teacher Choices in the Plants Unit document. It illustrates the options in the Pre-Lesson and how they will impact a sequence of activities in the Pre-Lesson and Activities 3.1, 3.2, and 3.4. Please refer to the Plants Unit Front Matter document and the Student Challenges and Teacher Choices in the Plants Unit document for more information about how you might make this choice.

<table>
<tr><td rowspan="2">Pre-Lesson (1-2 hr)</td><td>Gel Protocol
0.1GL: Keeping Track of Water in Solids and Liquids (60 min + overnight or several days)

AND

0.2GL: Plant Growth Investigation Setup (45-60 min over one or two days)
OR</td><td>  </td><td rowspan="2">When to plant radish seeds: Students should plant their radish seeds before beginning the Plants Unit so that plants will grow big enough for the Lesson 3 investigations. Allow at least 2-4 weeks from the Pre-Lesson to Lesson 3, depending on which Turtle Trail you choose.

How to plant radish seeds: Decide whether to follow a paper towel (PT or 1-Turtle Trail) a plant-growing gel protocol (GL or 2-Turtle Trail). Both versions give students the invaluable experience of watching plants grow, then analyzing plant gas exchange and mass change data. The Gel Protocol is more complex and rigorous, and there are more things that can go wrong. Two other differences include growing materials (paper towel vs. gel) and time (the gel protocol has two additional activities; some 2-Turtle activities may take longer, and the plants will need longer to grow).</td></tr>
<tr><td>Paper Towel Protocol
0.2PT: Plant Growth Investigation Setup</td><td>  </td></tr>
<tr><td>1
(50 min)</td><td colspan="3">For the 1-Turtle Trail, wait at least one week after planting radishes before beginning Lesson 1.
For the 2-Turtle Trail, wait at least three weeks after planting radishes before beginning Lesson 1.</td></tr>
<tr><td>2
(2 hr
5 min)</td><td colspan="3"></td></tr>
<tr><td rowspan="6">3
(2 hr
40 min)</td><td>3.1 Predictions and Planning about Radish Plants Growing (50 min)</td><td></td><td rowspan="6">To be ready, your plants should have at least two sets of leaves open and well developed (two cotyledons and two true leaves).
• If plants are ready, you can begin with the Mass Change investigation. While plants are drying, use extra radish plants (or another leafy plant such as a houseplant) for the light and dark investigation.
• If plants are not ready, we recommend using another leafy plant such as a houseplant for the Light/Dark investigation, giving your plants a little more time to grow. This will mean teaching the two Mass Change Activities (3.2 & 3.4) consecutively, but you will need <u>time</u> in between them for plants to dry! In this case, we recommend that you (a) partially complete the Evidence-Based Arguments tool after the Light/Dark investigation in Activity 3.3, (b) harvest the radish plants in Activity 3.2, (c) move on to Lesson 4 to teach Cellular Respiration and Photosynthesis, and (d) return to complete Activities 3.4 and 3.5 after plants have dried.</td></tr>
<tr><td rowspan="2">Gel Protocol
3.2GL: Observing Plants' Mass Changes, Part 1 (30 min)
OR
Paper Towel Protocol
3.2PT: Observing Plants' Mass Changes, Part 1 (30 min)</td><td>  </td></tr>
<tr><td>  </td></tr>
<tr><td>3.3: Observing Plants in the Light and Dark (60 min)</td><td></td></tr>
<tr><td rowspan="2">Gel Protocol
3.4GL: Observing Plants' Mass Changes, Part 2 (45 min)
OR
Paper Towel Protocol
3.4PT: Observing Plants' Mass Changes, Part 2 (45 min)</td><td>  </td></tr>
<tr><td>  </td></tr>
<tr><td>3.5: Evidence-Based Arguments about How Plants Grow (50 min)</td><td></td></tr>
</table>

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 Key Ideas and Practices for Each Activity:
Photosynthesis

Content Boundaries and Extensions (accordion)

Tab 4: Talk and Writing

Pre-Activity 0.1GL: Keeping Track of Solids in Mixtures (60 min + overnight or several days)

Tab 1: Overview and Preparation

Target Student Performance

Students will distinguish between solid mass (or dry mass) and total mass of materials consisting of water mixed with solid materials and use measurement techniques to determine the mass of solids in the mixtures.

This Pre-Lesson Activity is part of the Gel Protocol (2–turtle) and should only be taught if you have chosen this pathway (see Background Information for details).

Resources You Provide

You can do the investigation with students collecting their own data or with data coming from whole-class demonstrations. Materials lists for each are below.

For whole-class demonstrations:

- Calculators (1 per pair of students)
- Dry sponge
- Salt (about 100 g)
- Dry plant gel crystals (1 packet per class)
- Baby carrot
- Salt water mixture (about 10 g of salt in 50 ml of water)
- Ionic Grow (4 teaspoons, about 17 g; plus, an additional 4 teaspoons to make a mixture, see Setup below)
- Distilled Water (1 gallon per class)
- Glass Petri dishes (3)
- Digital Scale
- Scissors or knife
- Strainer/colander large enough for hydrated gel (1 per class)
- Bucket or bowl (>1 gallon) to hydrate gel overnight (1 per class)

For students working in pairs:

- Dry sponge (1 per pair of students)
- Salt (1t per pair of students)
- Dry plant gel crystals (1 packet per class)
- Baby carrot (1 per pair of students)
- Salt water mixture (about 1 cup of salt in 4 cups of water)
- Ionic Grow (1t per pair of students; plus an additional 4 teaspoons to make a mixture, see Setup below)
- Distilled Water (1 gallon per class)
- Small bowls, preferably transparent (3 per pair of students)
- Petri dish (3 per pair of students)
- Digital Scale (1 per pair of students)
- Calculator (1 per pair of students)
- Scissors or knife (1 per pair of students)
- Tape and marking pens (enough for container labels)
- Strainer/colander large enough for hydrated gel (1 per class)

- Bucket or bowl (>1 gallon) to hydrate gel overnight (1 per class)

Resources Provided

- Pre-Lesson 0.1GL Measuring the Mass of Solids in Mixtures Worksheet (1 per student)
- Pre-Lesson 0.1GL Grading Measuring the Mass of Solids in Mixtures Worksheet
- Pre-Lesson 0.1GL Measuring the Mass of Solids in Mixtures PPT
- Pre-Lesson 0.1GL Estimating the Mass of Solids Mixed with Water Handout (1 per student)
- (Optional) Measuring Plant Growth Video (https://www.youtube.com/watch?v=hVTZMLnhrJQ)

Setup

Setting up Part A:

- Prepare 2 small bowls for making the mixtures with the sponge and salt. Prepare tape and marking pens to label the bowls.

Setting up Part B:

- If using a warm oven, prepare 3 glass petri dishes, or other small ovenproof containers, per pair of students for drying the mixtures. If not using an oven, prepare 3 petri dishes per pair of students for drying the mixtures and a space in the classroom for the mixtures to sit out for several days until dried. If using an oven, prepare marking pens to label the containers. If not using an oven, you may also prepare tape to label the containers.
- Prepare a mixture of salt and water, enough to have about 1 teaspoon of mixture for each class.
- Prepare a pair of scissors or a knife per pair of students to cut the carrots into thin strips.

Setting up for Pre-Activity 0.2GL:

- Prepare a full gallon of the Ionic Grow mixture, either ahead of time, or during the 0.1GL Activity with students. Add 4 teaspoons (~17 g) of Ionic Grow mixture to a gallon (~3,800 g) jug of distilled water. This is the nutrient mixture that will hydrate the gel crystals.
- You will be hydrating the gel crystals to prepare them for planting the radish seeds in Pre-Activity 0.2GL. One package, or ~17 g of plant gel crystals absorbs about 1190 g of nutrient mixture to make about 1200 g of hydrated gel (enough to fill ~60 37mL test tubes). Instructions for hydrating the gel are included in the Directions in this Pre-Activity. You will hydrate the gel with the Ionic Grow mixture. *Note that the above are mass approximations, and the mass of your packet of gel crystals as well as the mass of the nutrient mixture it absorbs may be slightly different than our estimations.*

Print one copy of Pre-Lesson 0.1GL Measuring the Mass of Solids in Mixtures Worksheet and Pre-Lesson 0.1GL Estimating the Mass of Solids Mixed with Water Handout for each student. Prepare a computer and projector to display Pre-Lesson 0.1GL Measuring the Mass of Solids in Mixtures PPT.

Tab 2: Directions (accordion for individual steps in directions)

1. Use the instructional model to show students where they are in the course of the unit. Show slide 2 of the Pre-Lesson 0.1GL Measuring the Mass of Solids in Mixtures PPT.
2. (Day 1) Introduce the unit to students.

Tell students that in 3-4 weeks from now, they will begin to study plant growth. To prepare for that, they will set up the investigation by planting seeds prior to the unit, recording data, and making sure the plants grow over the next few weeks.

3. (Day 1) Pass out the Pre-Lesson 0.1GL Estimating the Mass of Solids Mixed with Water handout to each student.

Have students read the handout together. This will establish the problem for students.

- Discuss as a class the purpose for measuring the dry mass of the plants (to measure plant growth).
- Discuss the steps used to calculate percentages of dry mass.
- Tell students that they are going to follow these steps in their lab work today.
- (Optional) You can show students the Measuring Plant Growth Video (https://www.youtube.com/watch?v=hVTZMLnhrJQ).

4. (Day 1) Tell students that today they will practice finding the dry mass of mixtures.

This will help prepare students to find the dry mass of the materials they will use to plant their radish seeds in Pre-Activity 0.2 as well as to make calculations in Lesson 4 to prepare for explaining biosynthesis.

- Pass out one copy of Pre-Lesson 0.1GL Measuring the Mass of Solids in Mixtures Worksheet to each student.
- Show students slide 3 of Pre-Lesson 0.1GL Measuring the Mass of Solids in Mixtures PPT.
- Discuss the two methods for determining the mass of a solid in a mixture.

5. (Day 1) Part A

Using the worksheet and the PPT, walk through the steps together in order to find the dry mass of the solids before mixing them with water.

- Show students slide 4 of the PPT.
- If students are working in pairs, have them label the bowls for each of their materials as well as with their names.
- Measure the masses of the 2 bowls you will use for the sponge and salt mixtures. Add the solids to the bowls. Have students subtract the mass of the bowls and enter the masses of the solids in the first column of the table in Part C of their worksheets.
- Add water to each bowl. Have students subtract the mass of the bowls and enter the masses of the mixtures in the second column of the table in Part C of their worksheets.
- Note: The row for the gel crystals in Table C will be filled in on day 2 when you hydrate the gel crystals together as a class.

6. (Day 1) Part B

Using the worksheet and the PPT, walk through the steps together in order to find the dry mass of the solids after removing the water.

- Show students slide 5 of the PPT.
- If students are working in pairs, have them label the glass Petri dishes for each of their materials as well as with their names.
- Measure the masses of the glass Petri dishes.
- Add the solid/water mixtures to the Petri dishes. Have students subtract the mass of the Petri dishes and enter the masses of the mixtures in the second column of the table in Part C of their worksheets.

- Cut the carrots into thin strips so that they will dry more quickly and thoroughly.

7. Allow the mixtures to dry over several days or in an oven overnight.

Leave the mixtures in a visible place in the classroom and allow them to dry over several days. Alternatively, place the mixtures in a low-heated oven (<200 degrees) and allow them to dry over several hours. Caution: plastic petri dishes may melt in an oven!

8. (Day 2) Parts B and C

Finish the steps in the worksheet and Slide 6 of the PPT to calculate the percentage of the mixtures that are solids. *Note that when dehydrated, 1 teaspoon of Ionic Grow (out of the bottle) with a mass of 4.22 liquid grams is reduced to 0.14 grams of dry mass. In the Ionic Grow nutrient mixture, 4 teaspoons (17 liquid grams with 0.57 grams of dry mass) will be added to 1 gallon (3.79 L) of water, which has a mass of 3785 grams. The percentage of dry mass in this liquid mixture is* ***0.015%, which can be considered 0 for all calculation further on, although it is important for students to understand this magnitude of dry mass for when they later consider where the mass of their growing plants could have come from.***

9. (Day 2) Part D.

Have students complete Part D of the worksheet and discuss the questions on Slide 7 of the PPT.

- Tell students that when scientists measure plant growth, they use dry mass as an indicator of growth.

10. (Day 2) As a class, hydrate the plant gel crystals with the nutrient solution to prepare for planting.

Follow the steps in slide 8 of the PPT.

- If you haven't already prepared the nutrient mixture to hydrate the gel crystals, add 4 teaspoons (~17 g) of Ionic Grow to a gallon (~3800) jug of distilled water.
- Measure the mass of the dry gel crystals and have students record this information in Part C of the Worksheet. Place the gel crystals in a large bowl and pour the nutrient mixture on top of the crystals. Tell students to record the mass of the solid water mixture in Part C (crystals + gallon water + Ionic Grow)
- Let the crystals hydrate overnight.
- Ask students at this point to share their ideas on what plants need to grow. Ask students to predict whether or not plants will grow without soil in the gel. Ask students if they think the nutrient solution will explain plant growth.

Tab 3: Assessment

During the demonstration, note how students express their ideas about the difference between mass and dry mass or solid mass.

Tips

- When possible, lead the demonstrations in such a way that students can see what you are doing. Make use of a document camera, move classroom furniture around, position students strategically, elicit student volunteers to help with different steps, etc.
- Don't forget to carefully model for students how to account for the tare of the container when measuring the mass of the solids and mixtures.

Tab 4: Differentiation & Extending the Learning

Differentiation (Accordion)

Modifications (Accordion)

Extending the Learning (Accordion)

Pre- Activity 0.2: Plant Growth Investigation Setup (45 min over 1 or 2 days)

Tab 1: Overview and Preparation

Target Student Performance

Students will make initial measurements of the dry mass of radish seeds and growth media and start plants growing.

There are two different versions of this Pre-Activity to choose from depending on the depth of instruction you'd like to cover. Please refer to the Background Section at the beginning of this lesson plan for more information about each.

Gel Protocol (2-turtle)

- Pre-Activity 0.1: Keeping Track of Water in Solids and Liquids (60 min + overnight or several days)
- Pre-Activity 0.2GL: Plant Growth Investigation Setup (45-60 min over one or two days)

Paper Towel Protocol (1-turtle)

- Pre-Activity 0.2PT: Plant Growth Investigation Setup (45-60 min)

Pre- Activity 0.2GL: Plant Growth Investigation Setup (45 min)

Resources You Provide

- Large (37mL) test tubes or other clear receptacle (1 per student)
- Hydrated (w/ nutrient solution) gel crystals (completed in Pre-lesson 0.1) (1 per class)
- Digital scale (to 0.1g) (1 per group)
- Grow/Fluorescent Light
- Test tube rack
- Permanent markers and labels for test tubes
- Fresh packets of radish seeds (at least one seed per student or group plus a few more)
- Squeeze bottle to water plants

Resources Provided

- Pre-Lesson 0.2GL Plant Growth Investigation Setup Worksheet (1 per student)
- Pre-Lesson 0.2GL Grading Plant Growth Investigation Setup Worksheet
- Pre-Lesson 0.2GL Plant Growth Investigation Setup PPT

Setup

- For the gel crystals, 1 gram (~1/4 tsp) of crystals absorbs ~70g of water. Only ~0.25g of dry mass goes in to each 37 mL test tube. 1 packet (~17g) makes enough gel to fill ~ 60 37mL test tubes.
- Look for 20 X 150mm Pyrex glass test tubes, 37 mL capacity. If those are not available, clear plastic vials or small cups can work.
- Things inevitably go wrong when growing plants. Be sure to plant some extras. At least one extra radish plant per group of students is recommended.
- The squeeze bottle (e.g. ketchup bottles work well) is for future maintenance of plants.

- Print one copy of the Pre-Lesson 0.2GL Plant Growth Investigation Setup Worksheet for each student.
- Prepare your computer, projector, and speakers for the Growing Plants Investigation Video and the Pre-Lesson 0.2GL Plant Growth Investigation Setup PPT.

Tab 2: Directions (accordion for individual steps in directions)

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

Show slide 2 of the Pre 0.2GL Plant Growth Investigation Setup PPT.

2. Have students work in groups of four.

Each student will plant one radish seed in the plant gel.

- Four plants will allow each group to do at least one of the experimental treatments in *Activity 3.2 Plants in the Light and Dark* and have multiple measures to compare for *Activity 3.4GL Observing Plants' Mass Changes*.

3. Have students calculate the mass of the solid plant gel in their test tubes.

Have students follow the steps in Part A of their Pre-Lesson 0.2GL Plant Growth Investigation Setup Worksheet.

- Show students slide 3 of Pre-Lesson 0.2GL Plant Growth Investigation Setup PPT.
- Students should use the percentage they calculated from Pre-Activity 0.1 for how much solid is in the hydrated gel (should be ~1.4%). Students should understand that very little solid matter is added to the system through the addition of the Ionic Grow nutrient mixture. Following are our calculations through which you may choose to walk students or which you may just use as your own background knowledge.
- *Each gram of gel crystals absorbs 70 grams of water, so hydrated crystals are about 1.4% solid mass and 98.6% water. Each gram of water contains 0.015% Ionic Grow solids, so 1 gram of rehydrated gel contains 0.0089 grams of Ionic Grow dry mass.*
- *There are 0.25 grams dry gel crystals + 0.0038 grams dry Ionic Grow = ~0.25 grams dry mass in each 37 mL test tube*
- Note that radish seeds and the solids in the Ionic Grow mixture turn out to have tiny masses—less than 0.01 grams. Even though the scales show 0.01g precision, they aren't really that accurate, so the best way to deal with masses less than 0.01 g is to treat them as 0, or too small to measure. Otherwise, students will have a sense of false precision. For the purposes of this activity, when students are recording a mass that is less than 0.01g, they should be writing, "<0.01g." When doing calculations with this number, they should treat it as a zero.
- Tell students the dry mass calculations will be important later as they measure how their plants grow and try to determine where the mass of the growing plants comes from.

4. Have students calculate the mass of all solids in their test tubes.

Have students follow the steps in Part B of their Pre-Lesson 0.2GL Plant Growth Investigation Setup Worksheet.

- Show students slide 4 of Pre-Lesson 0.2GL Plant Growth Investigation Setup PPT.
- Remind students that the plants will need 3-4 weeks to grow before they are large enough to begin the rest of the Plants unit.
- Place the test tubes about 12-16 inches under the grow lights or in a sunny windowsill.

5. Plant maintenance

Use the table in Part C in the Pre-Lesson 0.2GL Plant Growth Investigation Setup Worksheet for students to track their observations and ongoing watering of their radish plants.

- Show students slide 5 of the Pre-Lesson 0.2GL Plant Growth Investigation Setup PPT.
- The gel is designed to water the plants for at least a week (probably 2) prior to needing additional nutrient mixture input.
- You may want to prepare another gallon of nutrient mixture (4 teaspoons Ionic Grow to 1 gallon distilled water) to add if needed to the tubes once most of the mixture has been extracted from the gel by the plants. Add nutrient mixture to the test tubes when the gel has subsided enough (~50% from initial volume) that the plants are in danger of wilting. Ketchup bottles (with the nozzles) work well for adding water. Only add an inch or two of the mixture at a time. Adding to much risks drowning the plants or creating an optimal environment for algal growth.
- The percentage of Ionic Grow dry mass in the nutrient mixture is 0.015%. Walk students through the appropriate calculation to determine the dry mass added each time to each system when the radish plants are watered. Note: the dry mass added to the tubes via the nutrient solution will be negligible.

Tab 3: Assessment

There is no assessment for this activity since students are setting up an experiment to learn from later on.

Tips

- If many of your students seem convinced that plants will not grow without soil nutrients, you may want to rehydrate a few gel crystals with water only to see if the radish seeds will germinate and start to grow (they should!).
- Allow students to take pictures of what they are putting into their test tubes as a reference for later on after plant growth.

Tab 4: Differentiation & Extending the Learning

Differentiation (Accordion)

Modifications (Accordion)

You can increase or decrease the level of complexity of the math problems students need to do here in order to calculate initial dry mass. For instance, students can weigh the radish seed, discover it weighs less than 0.01 grams, and record that as the mass, as it is essentially negligible. Or, students could weigh multiple radish seeds and calculate the average mass for each seed (recommended). Similar types of math problems could be done with the gel and nutrient mixture.

Extending the Learning (Accordion)

Have students make regular observations of their seeds as they grow over the next 3-4 weeks.

Pre- Activity 0.2PT: Plant Growth Investigation Setup (45-60 min)

Tab 1: Overview and Preparation

Target Student Performance

Students will make initial measurements of the dry mass of radish seeds and growth media and start plants growing.

Resources You Provide

- Small (e.g. 7X10 cm or ramekin) aluminum container (1 per student group)
- 20 radish seeds (1 set per student group)
- 15 cm of cotton yarn (1 per student group)
- **Brown** paper towel (1 roll or 2-3 sheets each student group) Note: brown, unbleached paper towel is required
- Markers/masking tape to label containers (1 per student group)
- A balance to measure masses (1 per student group)
- Large trays with at least 5 cm sides to put the containers in and hold water.(enough for all containers per class)
- Grow lights (highly recommended)
- 1 L of water (for starting seeds)
- 4 L of water with dilute nutrients (E.g. Ionic Grow, Miracle Grow, etc.) for use once seeds have sprouted.

Resources Provided

- Pre-Lesson 0.2PT Plant Growth Investigation Setup Worksheet (1 per student)
- Pre-Lesson 0.2PT Grading Plant Growth Investigation Setup Worksheet
- Pre-Lesson 0.2PT Plant Growth Investigation Setup PPT
- (Optional) Measuring Plant Growth Video (https://www.youtube.com/watch?v=hVTZMLnhrJQ)

Setup

- Things inevitably go wrong when growing plants. Be sure to plant some extras. At least one extra radish plant per group of students is recommended (note that this would double the number of radish seeds you'll want to have available to students).
- Print one copy of the Pre-Lesson 0.2PT Plant Growth Investigation Setup Worksheet for each student.
- Prepare your computer and projector for the Pre-Lesson 0.2PT Plant Growth Investigation Setup PPT.
- Optional: Be ready to view the Measuring Plant Growth Video.

Tab 2: Directions (accordion for individual steps in directions)

1. Use the instructional model to show students where they are in the course of the unit. Show slide 2 of the Pre 0.2PT Plant Growth Investigation Setup PPT.
2. Introduce the unit to students.

Tell students that in 2 - 4 weeks from now, they will begin to study plant growth. To prepare for that, they will set up the investigation by planting seeds today, recording data, and making sure the plants grow over the next few weeks.

3. **(Day 1) Pass out** Pre-Lesson 0.2PT Plant Growth Investigation Setup Worksheet **to each student.**

Read the handout together as a class or have students read it in groups to prepare for setting up the investigation. This will establish the problem for students.

4. **Establish the Problem.**

Optional: View the Measuring Plant Growth Video (https://www.youtube.com/watch?v=hVTZMLnhrJQ) to prime a conversation about how plants grow and the importance of measuring dry mass.

- This video focuses on the gel protocol. Since you are using the paper towel protocol, you can show from 0-2:50min and from 5:53-7:25min.
- Discuss as a class the purpose for measuring the dry mass of the plants.
- Tell students that they are going to walk through some of these steps together as a class today.

5. **Have students work in groups of four.**

Each student group will plant 20 radish seeds in a container.

- Four to six containers of plants will allow the class to do at least 1 replication of the experimental treatments in *Activity 3.3 Plants in the Light and Dark* and have multiple measures to compare for *Activity 3.2 and 3.4 Observing Plants' Mass Changes, Part 1 and 2*.

6. **Begin experimental setup and mass inputs**

Follow the steps in Part A: 0.2PT Plant Growth Investigation Setup Worksheet.

- Show students slide 3 and 4 of the Pre-Lesson 0.2PT Plant Growth Investigation Setup PPT.
- Have students label their containers.
- Have students poke a small hole or two in the bottom of their growing container and thread through the yarn, or another wicking object, (half inside, half outside) as a wick. This is so that water can be drawn up into the growing containers and keep all of the paper towel you will add moist.
- Have students count out 20 seeds for their container, mass, and record in the worksheet table.
- Have student groups crush up a few small strips of paper towel first and place them in the bottom of the container. Next, lay a strip or a small sheet of paper towel over these crushed up pieces (like a pie crust over cherries). This will allow you to sprinkle radish seeds on top of this flat piece of paper towel so that they don't get too saturated with water and so that the germination process is completely visible for students.
- Have students record the mass of the dry paper towel in their containers – either by taking it out and adding it back in or taring the container prior to adding the paper towel.

Tell students the dry mass measures will be important evidence for them to use later as they investigate where the mass of a growing plants comes from.

7. **Plant the seeds and place under grow lights.**

- Have students place their 20 seeds carefully on top of the flat piece of paper towel in their containers. Spread them out a bit for good germination.
- Have students carefully set their containers in the big class trays.
- Gently add water to the big class tray until the paper towel in the containers has wicked it up and is wet.

Remind students that the plants will need 1-3 weeks to grow before they are large enough to begin the rest of the *Plants Unit*.

Place the trays about 12-16 inches under the grow lights (highly recommended) or in a sunny windowsill.

8. Plant maintenance

Use the table in Part B in the Pre-Lesson 0.2PT Plant Growth Investigation Setup Worksheet for students to track their observations and ongoing watering of their radish plants.

- Show students slide 5 of the Pre-Lesson 0.2PT Plant Growth Investigation Setup PPT.
- Prepare about 4 L (~1 gallon) of a weak nutrient mixture (~1/2 of that recommended on the box/jar) to add to the containers once the cotyledons have turned green and the water is starting to dry up from the trays. Only add an inch or two of the mixture to the trays at a time. Adding to much risks drowning the plants or creating an optimal environment for algal growth.
- Note: It's important to have a discussion with your students about the dry mass of the nutrients that are added via the nutrient solution (which is negligible).

Class discussion:

Ask your students: 1) Do you think the radishes will grow in paper towel without soil?

Tab 3: Assessment

There is no assessment for this activity since students are simply setting up an experiment to learn from later on.

Tips

- If many of your students seem convinced that plants will not grow without soil nutrients, you may want to grow some radishes in other environments (like clear gel or a petri dish) to demonstrate otherwise.
- Allow students to take pictures of what they are putting into their containers and as their plants grow as a reference for later on after plant growth.

Tab 4: Differentiation & Extending the Learning

Differentiation (Accordion)

Modifications (Accordion)

You can increase or decrease the level of complexity of the math problems students need to do here in order to calculate initial dry mass. For instance, students can calculate the mass of a single radish seed or calculate the dry mass per unit volume of nutrients in the nutrient solution.

Extending the Learning (Accordion)

Have students make regular observations of their seeds as they grow over the next 1-3 weeks. These observations can be recorded in Pre-Lesson 0.2PT Plant Growth Investigation Setup Worksheet.