Can plants grow without soil?

Name: Teacher Guide _____ Date: _____

Instructions:

1. Gather your materials to build your experiment:
    a. Basil plant clippings, Recycled 2L bottles (2 per group), Small glass cups (2 of the same size per group), Scissors or knife (teacher supervision required to cut hole in bottle), Ruler, Permanent marker, Mesh material (for shade cloth; can use cheesecloth), Nutrients (e.g. plant food such as miracle-gro from hardware store is fine), Metal or silicone straw

2. Use a ruler and scissors to cut your basil clippings so they are the same size. Measure from the base to the tip of the stem, without including leaves.

3. Write down the length of your basil clippings on your data sheet.

4. Add about an inch of water to the bottom of both glasses. Be sure both cups have an equal amount of water.

5. Draw a line on the glass to mark the water level. As water evaporates over time, refill water up to the line.

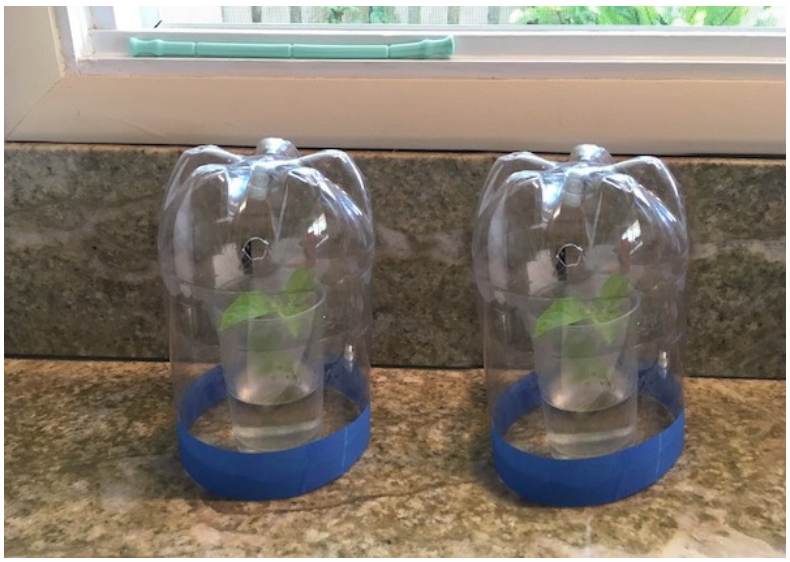
6. Place one basil clipping in each glass so the base of the stem is submerged (Fig. 4).

7. Cut the top off of your recycled 2L bottles to create the ‘grow domes‘ for your plants

8. With help from your teacher, cut a small hole in the side of each grow dome. Clean the domes.

9. Place a 'grow dome' upside down on top of each of your two basil plants

Example grow domes:



Test your Variable

10. Label each glass and corresponding grow-dome A or B.
    a. You will apply manipulations to the plant labeled A.
    b. Leave plant B alone to grow as your contol.
    c. Don't mix them up!
11. Allow both plants to grow under the 'grow domes.'
    a. Keep the water levels at the line drawn on each glass.
    b. Measure plant A and B periodically and write the heights on your data sheet.
12. Conduct trials to manipulate one of the three variables of carbon dioxide (CO2), nutrients, and light:

Trial #1: Extra CO2

a. Using the metal or silicone straw, blow into plant A to add CO2.
b. Set up a schedule so you can add CO2 as often as possible at regular and consistent intervals.

Trial #2: Extra Nutrients

a. Follow the instructions on your plant food mixture to add nutrients to plant A at regular intervals. Once a week should be fine, but you can also experiment with different intervals.
Note: Keep in mind, your plants are not in very much water, so be sure you don't add too much of the nutrient mix!

Trial #3: Limit Light

a. Place the mesh cloth over plant A to limit the amount of light available. Tape it down so it stays in the same position for the whole experimental period.
Note: You may need to double up the mesh cloth or use a different material to limit the light more fully.
b. Let both plants grow for the designated time, ensuring they both have enough water.

Name: Teacher Guide

Results will vary according to the variable tested. Look for students to make thoughtful observations and measurements.

Instructions: Measure your plant at regular time points with a consistent method. Make observations about the height, leaf count, and root structure.

This data sheet is for CO_2: Carbon dioxide (CO_2) was blown into plant A. Plant B was the control.

Variable You Tested: _____

Date	Plant A Height	Plant B Height	Observations
July 6	8 cm	8cm	Both plants were the same height and had no roots because they were just clippings. The leaves are barely reaching over the top of the glass. There are two layers of leaves - at the top, and in the middle
July 10	10 cm	9 cm	The plants have grown, but the one with extra CO_2 grew more. They still don't really have any roots. Plant A has an extra leaf.
July 14	12 cm	9.5 cm	The plants have grown a bit more, but plant A is still growing more. They have started to grow roots. Plant A roots are more full, plant B roots are mostly on the bottom of the stem. Plant A still has more leaves.
July 18	13 cm	10 cm	The plants are still growing in the same pattern, plant A is growing more and has more leaves. The roots are really starting to look different: plant A has some all the way up the stem, and plant B are just on the bottom.
July 22	15 cm	11 cm	Plant A is getting a lot taller than plant B and even has an extra layer of leaves. The roots continue to grow all the way up the stem in plant A.
July 26	17 cm	12 cm	Plant A is getting a lot taller than plant B and even has an extra layer of leaves. The roots continue to grow all the way up the stem in plant A.

Activity Questions

Answers will vary and will depend on which variables the students tested. Here we provide suggested answers for testing added CO_2 as well as notes on things to look for if added nutrients or decreased light is tested.

1. What variable did you test in your experiment?

   We tested carbon dioxide (CO_2). We added CO_2 to plant A by blowing into the hole in the dome on plant A. We also put a dome with a hole on plant B, but we did not blow CO_2 onto plant B. Plant B was our control.
   NOTE: Nutrient and light trials should also use plant A as the experimental unit (added nutrients or decreased light) and plant B as the control.

2. Which of your plants (A or B) grew longer? By how much?

   Plant A (the one that got CO_2 added) grew longer by 5cm in 20 days.
   NOTE: Nutrient trials are expected to follow a similar pattern, with added nutrients in plant A resulting in longer growth than in the control plant B. Light trials, on the other hand, are expected to have less growth in the shaded, experimental plant A and more growth in the control.

3. What else did you notice about the structure of your plant? Describe the growth of both plants. (Hint: look at other structures like the roots or leaves)

   Plant A grew more roots and leaves than plant B. Plant A had roots coming out of the stem very high up, and its roots are more full (more dense) than plant B. Plant A also has a second layer of leaves, but plant B does not.
   NOTE: Nutrient trials are also expected to have more root and leaf growth in plant A than in the control plant B. Light trials, in contrast, are expected to have less growth in the shaded plant A and more growth in the control B.

4. If another group looked at the same variable, how do your results compare to theirs?

   Answers will vary, but in general the experimental plants with added CO_2 or added nutrients will grow longer and with more roots and leaves. In the light trials, the shaded plant A should grow less. Look for students to make comparisons and notice differences between groups that are due to variation in individual plants as well as variations in the amount of CO_2 added and/or other variation that happens in experiments. This is a nice connection to the ideas of experimental replication and controls.

5. Compare the results across the three variable trials: CO_2, nutrients, and light. (Hint: did you observe differences in plant health, root structure, stem growth, quantity and/or color of leaves, etc.?)

   Answers will vary, but based on our trials and plant growth requirements, the nutrient added plants are expected to grow the most. Next fastest should be the CO_2 added treatment. The plants in the light treatment are expected to grow the least because plant A will be shaded, and plant B is not getting extra CO_2 or nutrients.

6. What variables contribute to plant growth? Use data from your class' experiments to support your statement.

   The amount of CO_2, sunlight, and nutrients seem important. Changing these variables made visible differences in the growth of plants. Students might also mention water or supports (like tomato cages or tying up vine-type plants such as lilikoi. Pests also affect plant growth (like aphids and slugs), as do microbes (like mold and viruses).

7. Why is it important to control as many variables as possible in an experiment? (Hint: why did each trial look at only one variable? Why did each trial have a control (plant B)?)

   In an experiment, we are usually looking to better understand the effect of something (like CO_2, light or nutrients), and if we change more than one variable at a time, it is difficult to know which one is responsible for any observed differences. However, many times variables will work together (in good ways or bad ways). Scientists call this interaction, and experiments can also be designed to look at the more complex situations with interaction!

8. What are the minimum requirements that plants need to grow?

   This question is designed to get at the performance expectation that plants get what they need to build their bodies chiefly from air and water. Plants definitely need water (although we did not experiment with water in this activity). Plants also definitely need sunlight to photosynthesize. And, plants need CO_2. Plants also need nutrients; from our experiments, we can tell that plants can grow fine with small amounts of nutrients (like our CO_2 treatment, where the plants grew well but only had the small amount of nutrients available in the tap water. Minimum requirements = water, light, CO_2, and nutrients.

   Soil is very valuable and performs a host of functions, like recycling nutrients, providing support, and holding onto water, but soil is not where the carbon comes from to build plants' biomass. The carbon used for building plant bodies comes from CO_2.