Where Do Plants Get Matter to Build Their Bodies?

Question: Where do plants get matter to build their bodies?

Core Content

SC-M-3.1.3 - Cells carry on the many functions needed to sustain life. They grow and divide, thereby producing more cells. This requires that they take in nutrients, which they use to provide energy for the work that cells do and to make the materials that a cell or an organism needs.

SC-M-3.2.1 - All organisms must be able to obtain and use resources, grow, reproduce, and maintain stable internal conditions while living in a constantly changing external environment.

SC-M-3.5.2 - Populations of organisms can be categorized by the function they serve in an ecosystem. Plants and some microorganisms are producers because they make their own food. All animals, including humans, are consumers, and obtain their food by eating other organisms. Decomposers, primarily bacteria and fungi, are consumers that use waste materials and dead organisms for food. Food webs identify the relationships among producers, consumers, and decomposers in an ecosystem.

SC-M-3.5.3 - For most ecosystems, the major source of energy is sunlight. Energy entering ecosystems as sunlight is transferred by producers into chemical energy through photosynthesis. That energy then passes from organism to organism in food webs.

SC-H-3.1.5 - Plant cells contain chloroplasts, the site of photosynthesis. Plants and many microorganisms (e.g., *Euglena*) use solar energy to combine molecules of carbon dioxide and water into complex, energy-rich organic compounds and release oxygen to the environment. This process of photosynthesis provides a vital link between the Sun and energy needs of living systems.

SC-H-3.5.1 - Atoms (e.g., carbon, nitrogen) and molecules (e.g., water) cycle among the living and nonliving components of the biosphere.

SC-H-3.5.2 - Energy flows through ecosystems in one direction from photosynthetic organisms to herbivores to carnivores and decomposers.

SC-H-3.6.1 - Living systems require a continuous input of energy to maintain their chemical and physical organization since the universal tendency is toward more disorganized states. The energy for life primarily derives from the Sun. Plants capture energy by absorbing light and using it to form strong (covalent) chemical bonds between the atoms of carbon-containing molecules. These molecules can be used to assemble larger molecules (e.g., DNA, proteins, sugars, fats). In addition, the energy stored in the bonds between the atoms can be used as sources of energy for life processes.

Objectives

Students will be able to:

1. Identify air (CO_2 gas) as the source of material for the “backbone” of molecules that comprise plants;
2. Identify light as the source of energy (but not material) used in building plants
3. Identify water as a compound that is taken up by plants, that “fills” plants, and that is given off by plants, but that does not comprise plant bodies;
4. Use their own data to show that plants do not “feed” upon soil;
5. Design an experiment to test the effects of factors such as water, nutrients, and light on plant growth.

Materials

- electronic balance (need to be able to weigh at least to ±.5 gm)
- seeds (large seeds such as bean seeds for observation; Fast Plants may be used during the experiment to speed its progress)
- magnifying glasses (for observing seeds, leaves)
- razor blades or sharp knife for bisecting seeds (teacher may choose to perform this procedure)
- small seedlings (one per group; plant seeds 1-2 weeks before the start of the exercise)
- small flower pots (small disposable cups with a few holes in the bottom will work)
- potting soil
- graduated cylinder or small measuring cup (for keeping track of water applied to plants)
- drying oven (a low temperature is needed (~65 C). A conventional cooking oven can be used at it lowest setting, or a drying box could be constructed out of wood, using several light bulbs as heat sources)
- small foil trays or plates (for drying soil, plants)

Procedure/Time

Framing the Question (1 period)

1. Give each group of 3-4 students a small potted seedling and several large seeds
2. Ask them to answer this question, "When plants grow, where do they get the "stuff" for their bodies?"
3. Students may wish to observe a seed that has been cut open (You may wish to cut the seed for them instead of providing them with a cutting implement)
4. Students will probably generate the following answers: from the soil, from the water, from the seed. Most likely they will not come up with air as a possible source of matter for growth. After they have discussed the question at length, the teacher may need to probe ("Do you thing plants need air?"…)

Designing the Experiment (1-2 periods)

1. Ask students to design an experiment to test whether soil, water, or seed is the source of material that makes up plant bodies
2. The basic experimental design they need to arrive at is: weighing seed and soil before planting; measuring and recording all water added to the pot; weighing soil and plant after several weeks of growth. Variation in experimental procedure is fine; students will need help in thinking their procedure all the way through, however.
3. Require each group to write out a step by step procedure (teacher can review these and trouble shoot; students will have a set of instructions to follow as the experiment proceeds). This procedure should include data sheets for recording anticipated data (fresh mass of seed, plant; dry mass before/after for weighing vessel, soil, plant; volume of water added; daily observations).

Performing the Experiment (2 periods to set up; 10 minutes 3 days/week; 2 periods to conclude)

1. Soil should be dried to begin experiment
2. Record the weight of soil, seed. Students will need help with taring. For dry weights, students should determine and record weight of foil plate to be used in drying
3. Dry several other seeds for 48 h @ 65 C; determine their dry masses; compute water content as percentage of fresh mass

4. Plant seeds (1 per container). Have each group do multiple pots if space and resources permit.
5. Place pots near a window where they will be exposed to sunlight
6. Establish watering schedule. Record volume of first watering and of subsequent waterings.
7. Determine mass of water/volume (if this hasn't been done before) so that water volume can easily be converted to mass
8. Observe germination and growth daily
9. Water as necessary; record volume of water used
10. When plants are large enough to be weighed reliably, terminate the experiment
11. Weigh a tray for each plant and a tray for each pot of soil
12. Place pot on soil tray, carefully remove plant (tray should catch any spilled soil. It is critical that no soil "escape"). Shake and brush soil from roots onto soil tray. Empty the rest of the soil from the pot onto the tray
13. Determine the fresh mass of the plant; record
14. Determine the wet mass of the soil; record
15. Dry the plant and soil for 2 days @ 65 C
16. Determine mass of dried plant in its tray; subtract mass of tray; record
17. Determine mass of dried soil in tray; subtract mass of tray; record
18. Interpreting the results by asking the students the following questions.

- How much did the original seed weigh?
- How much of that seed was water?
- So, how much of that seed was non-water "stuff"?
- How much did the plant weigh at the end of the experiment? Compare its mass to the mass of the seed. Could the seed at the beginning of the experiment have contained all the "stuff" that made up the plant at the end of the experiment? Why not?
- How much water did the plant contain at the end of the experiment? Compare this to the mass of the water in the seed.
- How much water did the soil contain at the end of the experiment?
- Did the water in the soil + the water in the plant = the water that was added to the pot? If it didn't, where did the rest of the water go?
- How much did the dried soil weigh at the beginning of the experiment? At the end? Do you think the plant "ate" the soil?
- If the plant didn't get most of its matter from the water, seed, or soil, where did it get the "stuff" with which it built its body? Could air contain matter that could be used to make solid things like plants?

Assessment

1. Students will create a written procedure
2. Data record sheets; data tables. Students should be asked to summarize their data in well-organized tables and/or graphs
3. Answers to questions. Questions, above, could be handed out to students in a worksheet to be completed.
4. Alternatives:
    - Report--students could be asked to write up their experiment as a formal report.
    - Oral report--students could be asked to report their findings to the rest of the class.
    - Poster--groups could produce a poster presentation of their work. This would model the type of presentations generally used in science fairs.

Variations on the Theme

- Use fresh mass/dry mass technique to test the effects of light color on plant growth. Plants placed under green cellophane could be compared to those grown under red cellophane.
- Plant seeds in sand. Make up different watering solutions using fertilizer in water to test the importance of nutrients such as N, P, and K.
- Measure O_2 and CO_2 release by placing plant in a sealed container and using O_2 and CO_2 probes (with Texas Instruments/Vernier CBLs). Compare daytime net release of O_2 with nighttime net release of CO_2.

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Designing the Experiment

Design an experiment to test whether soil, water, or seed is the source of material that makes up plant bodies. The basic experimental design is: weighing seed and soil before planting; measuring and recording all water added to the pot; weighing soil and plant after several weeks of growth.

This procedure should include data sheets for recording anticipated data (fresh mass of seed, plant; dry mass before/after for weighing vessel, soil, plant; volume of water added; daily observations).

What materials might you need?

What kind of data should you collect?

Do you need to know the mass of anything?

What might you need to know the mass of?

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Performing the Experiment

19. Soil should be dried to begin experiment
20. Record the weight of soil, seed. Students will need help with taring. For dry weights, students should determine and record weight of foil plate to be used in drying
21. Dry several other seeds for 48 h @ 65 C; determine their dry masses; compute water content as percentage of fresh mass
22. Plant seeds (1 per container). Have each group do multiple pots if space and resources permit.
23. Place pots near a window where they will be exposed to sunlight
24. Establish watering schedule. Record volume of first watering and of subsequent waterings.
25. Determine mass of water/volume (if this hasn't been done before) so that water volume can easily be converted to mass
26. Observe germination and growth daily
27. Water as necessary; record volume of water used
28. When plants are large enough to be weighed reliably, terminate the experiment
29. Weigh a tray for each plant and a tray for each pot of soil
30. Place pot on soil tray, carefully remove plant (tray should catch any spilled soil. It is critical that no soil "escape"). Shake and brush soil from roots onto soil tray. Empty the rest of the soil from the pot onto the tray
31. Determine the fresh mass of the plant; record
32. Determine the wet mass of the soil; record
33. Dry the plant and soil for 2 days @ 65 C
34. Determine mass of dried plant in its tray; subtract mass of tray; record
35. Determine mass of dried soil in tray; subtract mass of tray; record

Performing the Experiment

Item	Mass (g)
Mass of soil	
Mass of dried soil	
Mass of fresh seed	
Mass of dried seed	
Mass of extra seeds (fresh)	
Mass of extra seeds (dry)	
Mass of water in extra seeds	
Percentage of water in seeds	

Performing the Experiment

Item	Mass (g)
Mass of tray for plant	
Mass of tray for soil	
Mass of plant	
Mass of soil	
Mass of dried plant	
Mass of dried soil	

Watering Schedule

Date	Volume of Water Added	Mass of Water Added

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Interpreting the Results

1. How much did the original seed weigh?

2. How much of that seed was water?

3. So, how much of that seed was non-water "stuff"?

4. How much did the plant weigh at the end of the experiment?

5. Compare its mass to the mass of the seed. Could the seed at the beginning of the experiment have contained all the "stuff" that made up the plant at the end of the experiment? Why not?

6. How much water did the plant contain at the end of the experiment? Compare this to the mass of the water in the seed.

7. How much water did the soil contain at the end of the experiment?

8. Did the water in the soil + the water in the plant = the water that was added to the pot? If it didn't, where did the rest of the water go?

9. How much did the dried soil weigh at the beginning of the experiment?

10. At the end?

11. Do you think the plant "ate" the soil?

12. If the plant didn't get most of its matter from the water, seed, or soil, where did it get the "stuff" with which it built its body?

13. Could air contain matter that could be used to make solid things like plants?