The Plant Game

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Main idea:  Learn to strategize as a plant must do to survive in an ever-changing environment.

Objectives:

q  Learn that plants are living, adapting organisms.
q  Learn the impact that environmental changes have on living things.

Materials:

q  Paper clips
q  Colored-paper copies of leaves, flowers, and sugars
q  Water
q  100mL graduated cylinders, or other tall, thin containers
q  Small cups
Motivator: Ask, “How many people think that plants can be competitive?” Ask the students to explain how plants compete.

Questions: Before you begin the activity, ask:

q What challenges do plants face when growing in the environment?
q Do they have to struggle and compete the way animals do in order to survive?
q What environmental factors would make the difference between a plant living or dying?

Activity:

q Introduce game and rules. (See “The Plant Game: Plants’ Strategies for Growth” on the following pages.)
q Play!
q Discuss the strategies that different "plants" in your class adopted. Which ones worked? Which ones didn't?
q Discuss how different weather patterns could have changed the fates of some plants in the class. Why would some strategies have worked if the environment had been different?

Learning checks:

Should be accomplished during the discussion, above. Students should understand that most strategies
will work in some environments and not in others.

**Background:**

Though plants don't always look like they’re competing, they must struggle to survive just as animals do. This game explores the challenges plants face, and allows students to experiment with various ways of facing these challenges.

Plants must decide how to spend their energy (in the form of sugars). Should they put a lot of energy into growing roots, or leaves? If the season is hot and sunny, they'll want lots of roots so they can take up water and avoid wilting. If it's really rainy and cloudy, they'll want lots of leaves so they can photosynthesize and produce enough sugars to live even when it's cloudy out.

But plants can't know the weather ahead of time. So they have to budget their resources to come up with a winning combination of roots and leaves.

**Vocabulary:**

**Photosynthesis:** The process by which plants use sunlight, water, and carbon dioxide to create sugars.

**Extensions:** Can the students come up with a strategy they think will work in all environments? Test theories by repeating the game a few times.

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The Plant Game

To win at any game—football, Monopoly®, checkers, or cross-country—players must have a good strategy. In most cases, the best strategy is one that allows the player to “go on the offensive,” and take advantage of conditions and other players. At the same time, a good strategy also allows for “defensive play,” that is, being prepared for the worst thing that might happen. It may surprise you to learn that living organisms, too, can be said to have “strategics” for survival. The “strategics” that organisms “play” are genetically programmed, but responsive to environmental stimuli. Different species have evolved different “strategics” which allow them to “win” (survive) in their habitat. If they are removed from their particular habitat and moved to a different one, it’s unlikely that they will be able to survive successfully with the “new rules” or conditions.

In this lab, you and a partner will try to devise a strategy that will allow your plant to thrive and reproduce (make flowers). A winning strategy will be one that makes a lot of flowers before the first killing frost of autumn strikes! After all, in nature, the most successful organisms are those that
reproduce (make flowers). A wining strategy will be one that makes a lot of flowers before the first killing frost of autumn strikes! After all, in nature, the most successful organisms are those that reproduce, passing more of their genes to the next generation than do others of their species.

To make flowers you must first make both leaves and roots. Leaves are necessary because they are the part of the plant where photosynthesis occurs. It is the leaves that are the site where the sun’s energy is absorbed to power the conversion of CO₂ gas and water into sugar. The more leaves you make, the more photosynthesis your plant can carry out, and the more sugar that you will make. With this sugar, you can choose to make leaves, roots, or flowers. Therefore, making a lot of leaves might seem like a good strategy for rapid flower production. However, the more leaves your plant has, the faster “transpiration” will occur. Transpiration is the loss of water from the leaves. The plant must have a constant supply of water, therefore, you must also make roots. Roots are a plant’s only way to acquire water.

In this game, each leaf will be represented by a green leaf cut-out, each length of root by a paper clip, and each flower by a brightly colored flower cutout. The level of water in the “soil” will be shown by the water in a graduated cylinder.

**Materials:**

**Per Team of Students**

- 20 small vinyl coated paper clips
- 1 set of about 40 sugar tokens
- 1 set of about 10 flower cards
- 1 pipet and Pi-pump or bulb
- 1 small beaker to act as water reservoir
- 1 dowel or straw or wooden splint
- 1 set of about 20 green leaves
- 1 100 mL graduated cylinder
- 1 calculator or piece of scrap paper
- 1 Weather Report and Growth Costs Card
Playing the game

Starting the game:

Everyone begins with a full graduated cylinder, one leaf, and one paper clip "root"

1. Set up your “seedling” as shown in the diagram above. This resembles a newly germinated plant in the spring, when the soil is soaked with water from the spring rains. The tiny plant has already produced a short root and a cotyledon from materials in the seed. Now you and your partner will decide how the seedling will grow. But the weather will affect your decisions.

2. A plant in nature cannot control the weather. Neither can the teams playing this game! To randomly determine each day’s weather, Mother Nature (your teacher or another student) will roll a standard die. The roll, or “weather report” for the day may be sunny (a good day for making sugar), cloudy (not much sugar made), dry (a lot of water lost through transpiration), or rainy (add water to your graduated cylinder). Based on the number that comes up during each roll of the die, the Weather Table shows how much photosynthesis you can carry out, and how much water gain (rainfall) or water loss (transpiration) will occur. Rolling a 4 on the die, for example, means the day is warm and partly sunny. It’s sunny enough to allow your plant to make 3 sugars for each leaf on the plant. But it’s warm enough for the soil to lose 2 ml of water through each of the plant’s leaves.

Weather Table

<table>
<thead>
<tr>
<th>Number on Die</th>
<th>WEATHER</th>
<th>PHOTOSYNTHESIS</th>
<th>RAINFALL OR TRANSPERSION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Die</td>
<td>Weather Conditions</td>
<td>Photosynthesis</td>
<td>Transpiration</td>
</tr>
<tr>
<td>-----</td>
<td>------------------------</td>
<td>-------------------------</td>
<td>-----------------------</td>
</tr>
<tr>
<td>1</td>
<td>Chilly, downpour</td>
<td>no photosynthesis</td>
<td>gain 20 ml of water</td>
</tr>
<tr>
<td>2</td>
<td>cool light rain</td>
<td>make 1 sugar ( \times ) number of leaves</td>
<td>gain 5 ml of water</td>
</tr>
<tr>
<td>3</td>
<td>very humid, overcast</td>
<td>make 2 sugars ( \times ) number of leaves</td>
<td>lose 1 ml of water ( \times ) number of leaves</td>
</tr>
<tr>
<td>4</td>
<td>warm, partly cloudy</td>
<td>make 3 sugars ( \times ) number of leaves</td>
<td>lose 2 ml of water ( \times ) number of leaves</td>
</tr>
<tr>
<td>5</td>
<td>humid, sunny</td>
<td>make 4 sugars ( \times ) number of leaves</td>
<td>lose 2 ml of water ( \times ) number of leaves</td>
</tr>
<tr>
<td>6</td>
<td>sunny, very dry, hot</td>
<td>make 4 sugars ( \times ) number of leaves</td>
<td>lose 4 ml of water ( \times ) number of leaves</td>
</tr>
</tbody>
</table>

The Weather Report Card is a key to the weather conditions for each roll of the die. It also indicates the amount of sugar produced by photosynthesis, and the amount of water lost by transpiration.

After the day's weather has been determined, you and your partner will calculate the number of sugar tokens you'll receive and the change in the water level. For example, if you have 3 leaves and the roll of the die is "4" you will gain 9 sugar tokens (3 sugars multiplied by 3 leaves), and remove 6 ml \( \text{H}_2\text{O} \) from the graduated cylinder (2 ml multiplied by 3 leaves). To do this, take 9 sugar tokens from the token pile and put them next to your plant. Measure 6 ml of water out of the graduated cylinder using your pipet, and transfer the water to the discard beaker. Now you are ready for the next "day" (the next roll of the die). Whenever the roll of the die comes up 1 or 2, add water to your graduated cylinder from the beaker, according to the Weather Table.
3. As the days pass, you can save up enough sugars (tokens) to "make" a leaf (or leaves), root(s), or flower(s). Simply trade in the sugar tokens in exchange. Attach each to your growing plant.

**NOTE:** the more leaves you have, the faster you'll accumulate sugars, and the faster you'll lose water due to transpiration!

**Here are the “costs” for plant growth:**

To make a leaf, the cost is **10 sugar tokens.**

To make a root, the cost is **10 sugar tokens.**

To make a flower, the cost is **21 sugar tokens.**

You do not have to “buy” anything, even if you have enough sugars; you’re free to store sugars for as long as you wish.

If your roots are completely out of the water, you will not be able to carry out photosynthesis, and you lose more water due to transpiration. However, if you have stored sugars, you may use them to “buy” roots (or leaves or flowers) even while your roots are out of water. If your roots are out of water and you don’t have enough sugars to make more roots, you must wait for a rainy day.

4. The end of the game may be sudden and to the unprepared plant, crushing! Such natural signs as shorter days and longer nights autumn is approaching and the need to make seeds warn plants. As in nature, you won’t know exactly when the game will end. Mother Nature determines when autumn will approach. For example, Mother Nature may decide that the growing season might be as short as 15 days. That means that on day #15, Mother Nature will roll a pair of dice and if any identical pair comes up, it’s a frost! **GAME OVER!!!** If it’s not a pair, a single die will be rolled and the game will continue as before for another “day.” However, for each day after #15, the pair of dice will be rolled first to see if there’s a frost.

5. The winner of the game will be the team with the most flowers, symbolizing that their plant may have the best chance of making lots of seeds and producing many progeny during the next season!

**Data Analysis**

Write out the answers to the following questions using complete sentences.

1. How did your plant grow? On a sheet of graph paper, label the X-axis “Days” and the Y-axis “Total Number.” Then, using 3 different colored pens or pencils, plot a line for “Number of Roots” (paper clips), another for “Number of Leaves” and a third for “Number of Flowers” on the same graph. Compare your graph to that of the other students or to your own results from a different “season” of play.

   - Do successful strategies have a certain period in time where there is rapid leaf growth? Rapid
2. Divide the number of leaves by the number of roots in your plant as it looks at the end of the game. Write this leaf/root ratio on the board. When the whole class has calculated their leaf/root ratios, tally the results in the table shown below and prepare a histogram in which the "number of flowers" (Y-axis) is compared to the leaf/root ratio (X-axis).

<table>
<thead>
<tr>
<th>leaf/root ratio</th>
<th>total number of flowers</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.5</td>
<td></td>
</tr>
<tr>
<td>2.0 - 2.49</td>
<td></td>
</tr>
<tr>
<td>1.5 - 1.99</td>
<td></td>
</tr>
<tr>
<td>1.0 - 1.49</td>
<td></td>
</tr>
<tr>
<td>0.667 - 0.99</td>
<td></td>
</tr>
<tr>
<td>0.5 - 0.666</td>
<td></td>
</tr>
<tr>
<td>0.4 - 0.5</td>
<td></td>
</tr>
<tr>
<td>0.4</td>
<td></td>
</tr>
</tbody>
</table>

- What does the histogram tell you about the success of different teams' strategies?
- Does the graph look the same regardless of the weather?

3. Write a report that analyzes the success or failure of your strategy. Things to consider in your report:
   - How did you decide whether to make a root or a leaf with your sugars?
   - Did your strategy prepare you for bad weather, such as extended droughts or rainy periods?
   - Is it a good strategy to "buy a flower" as soon as possible, or are there advantages to waiting until later in the season?
- Did a good strategy of any kind develop? Or was the game going to drag on until later in the season?

- Did you have a winning strategy, or are you likely to become extinct?

## Scorecard

<table>
<thead>
<tr>
<th>Day Number</th>
<th>Roll of the die</th>
<th>Number of leaves</th>
<th>Photosynthesis factor?</th>
<th>Take how many sugar tokens?</th>
<th>total sugars</th>
<th>Make leaf, root, or flower?</th>
<th>Put how many sugars back?</th>
<th>New total sugars</th>
</tr>
</thead>
</table>