

**TEACHER VERSION**  
**(Suggested student responses included)**

## What do Plants Need to Grow? – The Four Question Strategy

(Reproduced with permission from: Cothron, J. H., Giese, R. N., & Rezba, R. J. (2006). Students and Research: Practical Strategies for Science Classrooms and Competitions. Dubuque: Kendall/Hunt Publishing Company.)

### Observe Natural Phenomena (Engage)

Do you have prior experience growing plants? Describe what you know about plant growth.

What do you observe about the seed germination set-up?

Summarize class observations about plant growth from seed to small seedling. (Be sure to include important events such as watering or fertilization, as well as basic observations derived from your senses including touch, sight and smell.)

### Pose Research Question (Explore)

Based on your prior experience with plants and your observations about plant growth from the seed germination demonstration use the 4-Question Strategy described below to develop potential plant investigation questions.

Here are some sample answers that students may list. However, the greater amount of time spent on these steps, the easier it will be for students to develop their investigation plan.

1) What materials are readily available for conducting experiments on plants?

Soil  
Water  
Seeds  
Light

Fertilizer  
CO<sub>2</sub>  
Container

2) How do plants act? (What do they do?)

Germinate  
Sprout  
Grow

3) How can you change the materials available to plants to affect their action?

**Water**  
*Amount of water*  
*Time when watered*  
*Frequency of watering*

**Fertilizer**  
*Amount of fertilizer*  
*Time when fertilized*  
*Frequency of fertilizing*

**Light**  
*Amount of light*  
*Direct or indirect*  
*Length of time exposed*

4) How can you measure or describe the response of plants to the change?

Time to germinate

Time to sprout

Time to grow a certain height  
Color of shoots  
Number of leaves

Measure the biomass  
Height of shoots  
Calculate the change in biomass

Based on your answers suggest 3 potential investigation questions.

## Develop Investigation Plan (Explore)

The next step would be to develop an investigation plan based on your research question.

Depending on your experience conducting experiments, your teacher may ask you to now develop your own investigation based on a teacher directed or a self-selected research question OR to review and then conduct an existing investigation. The following information will assist you in developing or reviewing your investigation plan.

First you will select one material to vary; this is the **independent variable** and will come from the list for question 3.

Then you choose which responses will be measured; these are the **dependent variables** and will come from the list for question 4. Dependent variables are called so because they are expected to vary with changes to the independent variable.

All other items from question 3 are **constants** and should be kept the same for each treatment type. Constants are necessary because

The **control** is the treatment that the other treatments will be compared to. The control is often the natural condition of the independent variable.

It is scientific practice to repeat each treatment and the control at least 3 times. These are known as **replicates** or repeated trials. Replicates are important because they reduce the effects of chance errors on the overall results. A greater number of replicates increases our confidence in the final results. (More replicates make it easier to see any results that deviate from the group and may be considered unreliable.)

At this point students are ready to begin a structured investigation of a plant growth variable. Students will continue to follow instructions found in their Plant-a-Plant Student Guide. Be sure to provide students with the *Laboratory Procedure & Student Worksheets* for the experiment they will perform.

Next students will use the *Review Investigation Plan* write a hypothesis based on what they think will happen and what their treatments are:

*Hypothesis: If I increase the amount of light to the seed/seedlings, then the biomass of the seedlings will increase.*

<i>Independent Variable</i>	<i>Amount of Light</i>	
<i>Treatment</i>	<i>Light</i>	<i>Dark</i>
<i># Trials</i>	<i>3</i>	<i>3</i>

Students should then visualize and record the steps that they need to take in order to carry out the investigation. As students improve in this skill, they should move from bullet points to writing this in paragraph form as scientists do when they write up their investigation in a scientific journal. In their plan, students should cover the independent variable, the control, the dependent variable, and the constants.

*Independent Variable: amount of light*

*Dependent Variable: biomass of sprouts, plant water content, root-shoot ratio, height of shoots, color of shoots*

*Constants: 12 maize seedlings, 2 flowerpots (approx. 0.75 liter volume), growing medium: gardening perlite or sand (2 liters), fertilizer containing basic nutrients (for example, Kristalon Start or Miracle Gro), distilled water- 2 liters*

*Control: Plants in light treatment*