

Exploration Phase: Rainbow to Grow Lab

MS-LS1-5: Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.

Driving Question: How can different light colors affect plant growth?

Purpose of the Rainbow to Grow Lab Activity: The purpose of *Rainbow to Grow Lab* is for students to develop a hypothesis that addresses light color and plant growth; design and execute an experimental design; and collect data to use as evidence to support or refute their hypothesis. During this activity, students investigate the effects of colored cellophane on plant growth through experimentation and data collection, just as horticulturists and plant biologists do in their laboratories. The *Rainbow to Grow Lab* provides students with the opportunity to develop unique experiments to observe growth of different plant species growing under different light colors.

Learning Objective Addressed in the Exploration Phase: Students construct experiments to measure the impact that different colors of light have on plant growth.

Time in Minutes: 160

Background Information:

Using chlorophyll, plants process sunlight energy, carbon dioxide and water to produce oxygen and glucose (a monosaccharide). The glucose is used to energize and fuel a plant's metabolic processes. Energy from the sun is the catalyst for photosynthesis, but some plants need different amounts and wavelengths of sunlight to successfully grow. Providing a plant with maximum light does not imply that it will always grow better; some plants even suffer in these extreme light conditions. Instead, varying concentrations of light quality allow plants to grow successfully in different environments. Another aspect of light quality is the specific wavelengths of light absorbed by a plant. Plants absorb certain wavelengths of visible light during photosynthesis and either filter through or reflect other wavelengths. In addition, they use the presence of certain wavelengths as information about the environment and as triggers for directed growth. Thus, plants in the shade of other plants may often be triggered to put all growth into elongation of the main stem, in order to escape the shaded areas. For plants under trees, growth may be directed towards the sides of the plant, where they can pick up the unfiltered wavelengths of visible light from the sun.

Materials

Student Materials: StudentHandoutExploration1_RainbowGrowLab
StudentHandoutExploration2_DataSheet
StudentHandoutExploration3_DataAnalysis
Experiment supplies (see **Experiment Supplies** listed below)

Teacher Materials: TeacherHandoutExploration1_RainbowGrowLab
TeacherHandoutExploration2_Rubric

Experiment Supplies:

- Two (2) sets of 30 clear plastic test tubes for \$13.99 at this [link](#). Each student needs four test tubes in total.
- Six (6) plastic test tube racks for \$5.99 each at this [link](#).
- One (1) pack of 6 plastic squeeze bottles for \$9.99 at this [link](#).
- One (1) bag of sand (5 lb.) for \$4.98 at this [link](#).
- One (1) pack of multicolor cellophane sheets for \$9.99 at this [link](#).
- One (1) roll of black cellophane for \$8.99 at this [link](#).
- One (1) bag of mung bean seeds (1 lb.) for \$12.10 at this [link](#).
- One (1) bag of radish seeds (1 lb.) for \$19.95 at this [link](#).
- One (1) bag of corn seeds (approx. 1000 count) for \$5.69 at this [link](#).
- Cardboard (used to create sleeves for test tubes; see **Set-up Instructions** below). If spare cardboard boxes or sheets are already available, they will work in this lab.
- Twelve (12) rulers, available at any general merchandise store (Walmart, Dollar Tree, etc.) for about \$1.00 each.



- Twelve (12) pens, available at any general merchandise store (Walmart, Dollar Tree, etc.) in a pack of 8 for about \$3.00.



- Twelve (12) scissors, available at any general merchandise store (Walmart, Dollar Tree, etc.) for about \$3.00 each.



- Paper plates, available at any general merchandise store (Walmart, Dollar Tree, etc.) in a pack of 50 for about \$4.00.



- Tape, available at any general merchandise store (Walmart, Dollar Tree, etc.) for about \$7.00.



- Paper, available at any general merchandise store (Walmart, Dollar Tree, etc.) in a pack of 500 sheets for about \$4.00.



Note: The materials list is designed to accommodate 24 students -- six different student groups, with each group composed of four students. Materials such as squeeze bottles, scissors, pens, and rulers can be reused from one class to the next. Materials such as paper, tape, plates, seeds, sand, and cardboard, are usually ordered in bulk so it is relatively easy to have enough for your entire class or can be purchased easily by making a quick run to a grocery store. If you do find yourself with limited supplies, I recommend substituting the more expensive materials with cheaper alternatives, such as planting seeds in small plastic cups instead of test tubes.

Activity Introduction: Research Questions

In the Engagement phase, students were presented with a scenario where Dr. Doust asked students to help him determine how to replicate a rainforest's lighting conditions in his lab to BEST support a mysterious plant from the Amazon rainforest. Students were then tasked to generate questions about plant growth and optimal growing conditions in this scenario. Using their questions submitted to the virtual question board, we transitioned into the Driving Question, "how can different colors of light affect plant growth?"

The narrative continues: "We wrote back to Dr. Doust, explaining that we are unsure which environment would be best for the Amazonian plant because we do not know how different colors of light can affect plant growth. Dr. Doust thinks we should explore this scientific phenomenon! He believes that some background research will help our class better understand how plants grow in different environments."

I explain that "Dr. Doust suggests a few plant species for us to use as a model specimen as we explore this topic. He also thinks that we should use different colors of cellophane sheets to simulate different colors of light."

I prompt student groups to develop a research question about light color and its effect on plant growth. Provide the available cellophane colors (red, green, orange, pink, blue, orchid or yellow) and the types of seeds available (radish, mung bean, or corn) that they may refer to as they develop their questions. An example of a typical research question is, "Do mung beans grow taller in red light than in green light?"

While students discuss, create and present a new Padlet; title it, *Research Question Padlet* for students to later submit their question. I use this Padlet to ensure that each group has developed an appropriate research question to investigate during the *Rainbow to Grow Lab* activity.

In this phase of the lesson, students design experiments to test the effects of different wavelengths of visible light on plant growth. The experiments are based on student-generated research questions, where students use observations and collected data to answer their research question. Using data collected from their experiments, students develop graphs to aid in visualizing and identify patterns within their data set. These patterns assist students in explaining the relationship between colors of light and plant growth.

Note: The 'Research Question Board' is the second virtual question board you will create on Padlet. First mentioned in the Engagement phase handouts, Padlet is a blank-canvas site that allows users to create a board for others to make posts on. It is entirely free, and incredibly useful in creating digital question boards in the classroom. (To create an account and try out the website, follow this [link](#).) Students access the Padlet through a shared link and need iPads or other technology to participate in class activities.

I task student groups to designate one member to be the Spokesperson. After generating a research question, the group's Spokesperson posts their research question onto the Research Question Board (aka, Driving Question Board). As students submit their questions, I moderate which questions can be presented on the Padlet board (this is done by selecting 'Require Approval' in the 'Settings' of the Padlet). I review the research questions submitted, then accept questions that compare two specific light colors on a specific plant species. If two submissions include the same light colors and plant species, I allow the two student groups to do one of the following: 1) change either their plant species or light colors; or 2) or conduct the same experimental design and then have the two groups compare similarities and differences in their data. Each student group will grow at least two plants for each treatment (technically termed replicates) to account for natural variation and experimental error. The description and data tables below are set up for two plants per treatment, but extra columns could be created for more plants, if time and space permit.

Note: As student groups their research questions, I discuss the collaborative effort behind scientific work and how researchers often use several viewpoints and opinions to strengthen their work's credibility. Collaborative work between student groups helps students to identify patterns within natural phenomena; this allows for explanations to develop and strengthen. In addition, use of replicate plants (more than one plant per treatment) introduces the students to the idea that experimental results are strengthened when multiple replicates show the same effect.

The narrative continues: "Now that you all have developed a research question, Dr. Doust wants you to seek an answer to your question!"

Procedure – Part 1: Experiment Design & Construction

Facilitate students through designing an experiment to investigate their research questions. I task student groups to collaborate on their experimental design, such as identifying their variables, methods, materials, and data they intend to collect. In their handout

(StudentHandoutExploration1_RainbowGrowLab) instruct students to identify the following:

- Their group's research question
- The independent variable, dependent variable, and control variables
- The materials needed to construct their experiment
- Their hypothesis
 - Rather than a research question of "how will ____ affect the growth of ____?" students construct a cause-effect claim to test, such as "if a ____ plant receives _____, then _____ will happen."
- Identify the qualitative and quantitative data they plan to collect to test their hypothesis.

To ensure my students are familiar with the different types of variables in an experiment, I review the following definitions with them:

- Independent variable: the variable that you are *changing* during the experiment
- Dependent variable: the variable that *changes in response* to the independent variable during the experiment
- Control variable: the variable that *stays the same* during the experiment

Management Tip: Concerning the different range of academic strengths of my students, I employ different methods of differentiation for the designing, constructing, and conducting student experiments. For students with learning differences and special needs, I provide additional assistance when preparing their cardboard sleeves, planting seeds in test tubes, and preparing cellophane filters. Furthermore, I allow their experimental design to rely more on qualitative measurements, such as color, texture, and direction of growth. For students in gifted subgroups, I present the challenge of extending upon the basic outline for their experimental designs. This includes (but is not limited to) collecting four sets of qualitative and quantitative data instead of two, as well as incorporating a statistical parameter to their graphs, such as a box and whisker plot.

As student groups develop their experiments, I walk around the class and ask for justifications behind their ideas for their hypothesis and experimental design. This helps me monitor if they are developing appropriate projects with plausible hypotheses, rather than theory-free guesses.

Once students have outlined their hypothesis, materials requested to set up their experimental design, and proposed data they plan to collect, I monitor groups as they construct their experiments. Refer to the instructions for using these tools, provided in TeacherHandoutExploration2_Instructions.

Safety:

- Monitor students as they conduct their experiment and collect their data. Reinforce strict lab safety protocol: no running, rough housing, etc.
- Monitor students for potential allergies to plants. If students are sensitive to the seeds or plants restrict their direct contact with the seed/plant during data collection.
- Demonstrate how to properly work with all lab materials, including plant care and light filters, before experimentation begins. Reinforce gentle care and caution with these items to prevent damage to lab materials.

Management Tip: Because students are using several materials to construct their experimental design, allocate enough time for students to clean up their lab stations before the end of class.

Note: The use of an appropriate control in this experiment is important. If the experiment was only contrasting the effects of unfiltered light versus light filtered by the different colored cellophanes, there would be the problem that the cellophane both filters out all but a few wavelengths of light AND reduces overall light amount. The way to remove the confounding effect of varying light amount is to use the black cellophane as the control, because this reduces the amount of ALL wavelengths more or less equally, leaving color as the only variable that can be changed.

After each student group completes constructing their experiments, task students to place their test tube racks on a windowsill or near a window (in your classroom, in the lab, etc.). At the end of the class period, task students to complete the following assessment question located on StudentHandoutExploration1_RainbowGrowLab. I use this question to assess what students know before they collect data during their experiments.

Assessment Question: How can qualitative and quantitative data help you to determine if a plant growth is responding to the independent variable? Give AT LEAST one example of qualitative data and AT LEAST one example of quantitative data, then explain your examples are helpful.

➔ *Answers will vary, but should mention some of the following:*

Qualitative: thick/thinness of stems, thick/thinness of roots, texture of leaves, condensation within the planting vessel, direction of growth, etc. These factors visually indicate whether a plant is receiving enough nutrients to live, as well as display whether one environment gives more nutrients than another. Visual assessment can help determine the plant's success in the tested environment.

Quantitative: average number of secondary roots, number of seeds that sprouted, number of leaves, height of plant, size of leaves, size of roots, etc. By measuring and quantifying the differences between the plants, it allows for the determination of which environment benefits plant growth more. Simple comparison between numbers will display which plant grew taller, more roots, larger leaves, etc. and the more optimal environment.

Procedure – Part 2: Data Collection

Over the next two weeks, students collect data each day; this usually takes only 10 minutes out of the class period. In addition to watering their plants, students use this time to make observations and collect quantitative and qualitative data.

There are four tables in StudentHandoutExploration2_DataSheet, two for quantitative data for the control and experimental treatments, and two for qualitative data for the control and experimental treatments. In the spaces under the column labels, students fill the traits they are measuring, such as 'Height' for Trait 1 or 'Leaf Count' for Trait 2. These traits should mirror the types of qualitative and quantitative observations they outlined in Student Handout Exploration1_RainbowGrowLab. Below is an image of the quantitative data table for the control plants is provided.

Quantitative Data: Control Plants (Black Cellophane)

Time	Trait 1:		Trait 2:	
	Control Plant 1	Control Plant 2	Control Plant 1	Control Plant 2
1				
	Average:		Average:	
2				
	Average:		Average:	
3				
	Average:		Average:	
4				
	Average:		Average:	
5				
	Average:		Average:	

Note: I ensure that students plant at least three experimental plants and three control plants because there will always be variation between plants as they grow (no two plants ever look exactly alike, even if they are genetically identical). In addition, genetic variation within a species will create additional differences. The seeds of each plant species suggested for these experiments are all genetically identical, but in wild populations, genetic variability within a species can also lead to differences in growth. Variation between the plants that the students will grow for each treatment may be due to differences in temperature, moisture, light, etc., that could not be totally eliminated in the experiment. By collecting data over two plants in each environment, a more meaningful comparison can be made between the control and experimental treatments.

In total, students should measure six plants: three control plants (black cellophane) and three experimental plants (colored cellophane). In the tables provided, students record the growth of the control plants in the tables labeled “Control Plants,” and record the growth of the experimental plants in the tables labeled “Experimental Plants”. This allows students to observe the differences in growth between the control and experimental treatments and the variation of growth within one species (between the three replicate plants in each treatment). The first two tables in the handout are used to record quantitative data, and the last two tables allows students to take notes over their qualitative observations.

In the quantitative data tables, there are ‘Average’ boxes under each trait for each day. In this box, students identify and record the average of the measurements from the three plants in each treatment. Students repeat this each day, for both the control and experimental environments they are observing.

Management Tip: Because my groups are typically composed of four students, I task each group to divide the task of data collection evenly among each group member. I suggest that two students collect data from the control plants, while the other two collect data from the experimental plants. This ensures that all students have the opportunity to complete data collection in the allotted 15-minute timeframe.

Procedure – Part 3: Data Analysis

During Part 3, students collect data for two weeks, complete their data tables, and transition their data to a graph format to display their data (see StudentHandoutExploration3_DataAnalysis). Then, I task each group to review the data they recorded in their tables and graphs look for and overall trends in quantitative data they noted during their experiment.

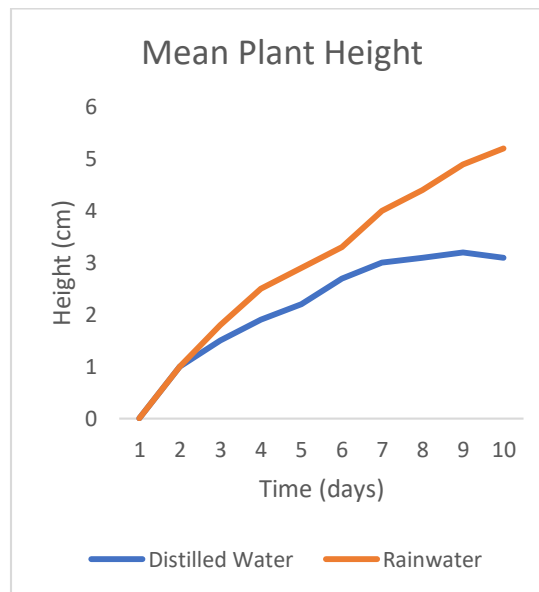
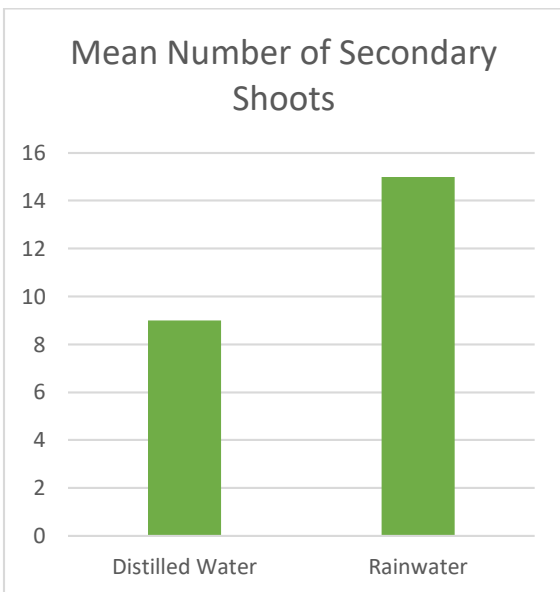
Note: Middle school students may not have a strong understanding of how to graph data, so I review how to determine the best method for graphing data, as well as the important components of a graph (labeling X and Y axes, graph title, data labels, etc.). Depending on the data students choose to collect, they typically make either a bar graph or a line graph. Remind students that bar graphs represent independent numbers for comparison, while line graphs show how numbers change over time. Also, mention that all graphs should be titled, and axes should be labeled with increments and units.

With their group, students decide how to represent their data on a graph, then graph their data (the averages of each trait) on the StudentHandoutExploration3_DataAnalysis handout. Monitor students as they construct their graphs to ensure that they are accurate and readable. Ask questions, such as “do you see a trend or pattern in the data you collected?” and “what do you think that means about your variable and how it affected your plant? Graphs help students make sense of their data, as well as visualize and identify patterns within their data. Students use these patterns in the Explanation phase to construct explanations that support or refute their hypothesis.

I instruct students to review the qualitative observations made throughout the two weeks. In their handout, students note and explain the overall observed qualitative changes in their control plants and in their experimental plants. Similar to above, their explanations are used in their presentations during the Explanation phase.

As a way to assess students' understanding of graph analysis they complete the following question, located at the end of their StudentHandoutExploration3_DataAnalysis handout.

Quick Assessment: Jamie wants to test her claim that plants watered with distilled water will grow better than plants watered with rainwater. She grew five plants that she watered only with distilled water and five that she watered with rainwater. After allowing her experiment to run for ten days, she recorded her data in the graphs below: 1) Mean Number of Secondary Shoots and 2) Mean Plant Height. Was Jamie's claim correct? Provide evidence to support your answer.



➔ *Potential Correct Response: Since plants grown in rainwater produced more secondary shoots and grew taller than plants grown in distilled water, this might suggest that rainwater was more beneficial than distilled water.*

At the end of class, I collect StudentHandoutExploration1_RainbowGrowLab, StudentHandoutExploration2_DataSheet, and StudentHandoutExploration3_DataAnalysis. I use TeacherHandoutExploration3_Rubric to assess students' responses in **Part 1:** Experiment Design & Construction and **Part 3:** Data Analysis.

How To: Prepare Cardboard Sleeve

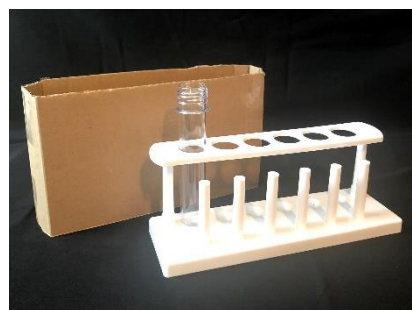
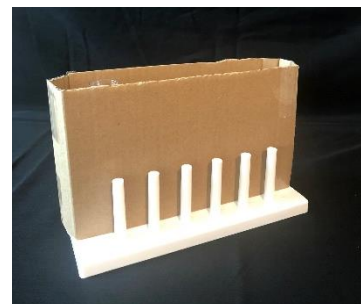
Step 1: Mark the height of a test tube on a piece of cardboard. Draw a straight line across the entire piece using a pen and ruler. Once you have drawn this line, cut along the line with scissors (the line will help you cut a straight edge).



Step 2: Repeat Step 1 with another piece of cardboard, so that you have two equal-sized pieces. Make sure that each piece is NOT taller than the test tube.



Step 3: Wrap one piece of cardboard around the test tube rack. Note where the cardboard bends around the rack; it needs to keep this shape! With the other piece of cardboard, tape one end to the first piece of cardboard. Continue wrapping around the rack, then tape the end of the second piece to the end of the first piece. Now you have a cardboard sleeve! Make sure that the sleeve is removable from the rack and covers the test tube WITHOUT being taller than the tube.

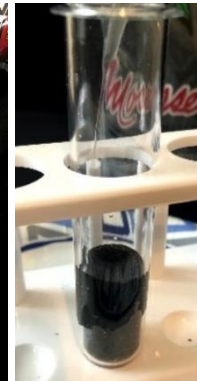


How To: Plant Seeds

Step 1: Make a funnel by rolling a piece of paper into a cone shape. Place the funnel into a test tube, then place the test tube rack onto a paper plate. This will help to keep your workspace clean as you pour the sand into the test tubes!



Step 2: Pour the sand into the test tube until the sand has filled about one inch of the bottom of the test tube. Using the squeeze bottle, squeeze water into the sand until all of the sand is moist. Repeat this process of adding sand and water in small increments until the test tube is completely filled (be careful not to have the sand overflow out of the test tube).



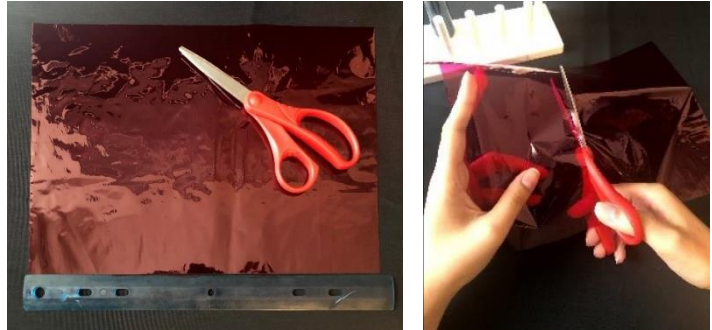
Step 3: Place a seed in the center of the test tube. Push the seed into the sand until it is completely covered. If necessary, add more sand on top of the seed to fully cover it to a depth of approximately 1.5 - 2 times the width of the seed.



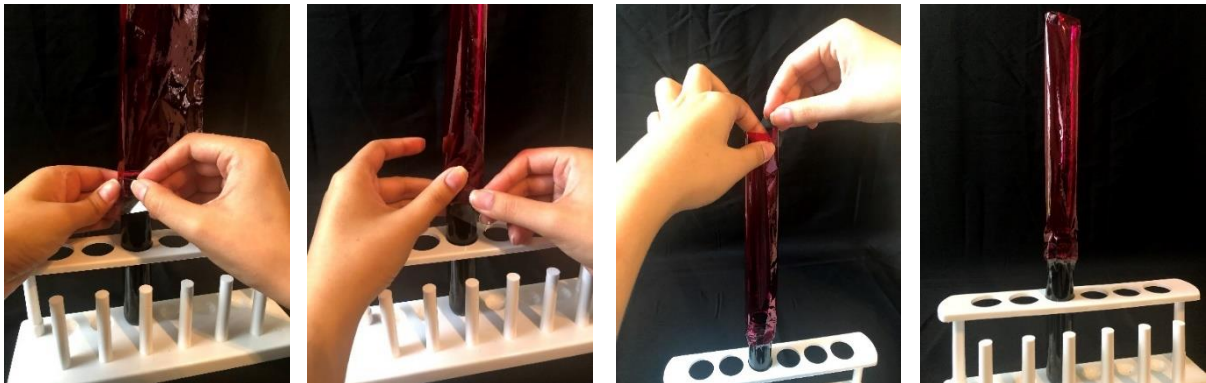
Step 4: Repeat Step 1 through Step 3 until you have prepared six test tubes total.

How To: Prepare Cellophane Filter

Step 1: On a colored cellophane sheet, measure and cut a 4 x 8.5 inch strip. This is easiest if you measure along the long side of the cellophane, then cut upwards.



Step 2: Wrap the cellophane around the top of the test tube. The 4 inch end should be at the bottom; the cellophane should be tall and SLIGHTLY overlapping! Tape the cellophane onto the test tube to secure the sheet. At the top of the cellophane, tape the two loose ends so that the cellophane creates an enclosed 'tube' that fully surrounds the test tube. If using mung beans, make a looser funnel shape at the top to accommodate the expanding leaves as it grows.



Step 3: Repeat Step 2 for three experimental plants with COLORED cellophane, as well as three control plants with BLACK cellophane. Black cellophane acts as a control in this experiment, since it lowers the amount of light transmitted through to the plant but does not change the relative amounts of the different wavelengths of light. This enables the experiment to only focus on light color as an influence on plant growth, without the confounding effect of different amounts of light.

Exploration Phase: Free Response Grading Rubric

I use the following rubrics to evaluate student responses throughout the Rainbow to Grow Lab activity. The rubric I use for **Part 1: Experiment Design & Construction** is used to evaluate students' experimental design; while the rubric for **Part 3: Data Analysis** is used to evaluate students' data analysis.

Part 1: Experiment Design & Construction

	Below Average Performance (0-1)	Average Performance (2-3)	Above Average Performance (4)
Q.1	Information is incomplete or written incorrectly; research question is not related to variables of light and/or to plant growth.	Research question provides correct and complete information; question is related to variables of light and plant growth.	Research question provides correct and thorough information; clearly articulates the variable of light and its relation to plant growth.
Q.2	Hypothesis is missing or incomplete; hypothesis is unclear or only implied elsewhere.	Hypothesis relating variables to predicted results is basic/general; hypothesis is based on flawed logic; hypothesis does not/is loosely related to research question.	Hypothesis clearly and reasonably states relationship between variables and predicted results. Hypothesis directly connects to research question.
Q.3	Variables written incorrectly; Independent, Dependent, and/or Control Variables identified incorrectly.	Variables incomplete; description is incomplete.	All of the following variables included: independent variable, dependent variable(s), control variable(s)
Q.4	Materials are not listed; materials list is incomplete.	XXXXXXXXXXXXXX	All of the following materials used are listed: choice of colored gel light filter, choice of seed, and an image with all materials in use (including general materials such as CD cases, sand, cardboard, and zip lock bags)
Q.5	Qualitative and quantitative data is incomplete or missing. Data does not relate to research question at all.	Data loosely relates to research question.	Selects two qualitative and two quantitative data that directly addresses research question.

Total points: ____/20

Part 3: Data Analysis

Question	Below Average Performance (0-1)	Average Performance (2-3)	Above Average Performance (4)
Qualitative Data summary	Summary is incomplete or missing; summary does not show analysis of qualitative data.	Summary is complete, but lacking depth in analysis of data. Does not address all prompts.	Summary is complete and analyzes qualitative data fully. Addresses initial results, final results, and how data changed over time.
Graph 1	Graphs displaying data are incorrect or missing variables (title, key, etc.)	The graph displays recorded data.	The graph clearly displays results and trends in data; graph contains all necessary elements.
Graph 2	Graphs displaying data are incorrect or missing variables (title, key, etc.)	The graph displays recorded data.	The graph clearly displays results and trends in data; graph contains all necessary elements.

Total points: ____/12

Student name: _____ Date: _____

Rainbow to Grow Lab

Background Information: Photosynthesis is a unique energy conversion process that enables growth and survival for green plants and other light dependent organisms. Plants capture the energy of the sun in chlorophyll, and use energy, water and carbon dioxide to create oxygen and glucose (a monosaccharide). The glucose that is produced during this chemical reaction is used to energize and fuel a plant's metabolic processes. Energy from the sun is the catalyst for photosynthesis, but not all wavelengths of light are equally as effective for photosynthesis and plant growth.

Purpose: We wrote back to Dr. Doust, explaining that we are unsure which environment would be best for the Amazonian plant because we do now know how different colors of light can affect plant growth. Dr. Doust thinks we should explore this scientific phenomenon! He believes that some background experimental research will help our class better understand how plants grow in different environments. Dr. Doust suggests a few plant species for us to use as a model specimen as we explore this topic. He also thinks that we should use different colors of cellophane sheets to simulate different colors of light so that we can compare growth under different light environments. Now that you have developed a research question, Dr. Doust wants you to seek an answer to your question!

Safety First! During the Rainbow to Grow Lab, you will work with living plants and delicate light filters. Be aware and cautious of the materials you will use to construct your experiments. When I demonstrate how to use lab materials, be sure to follow instructions and take care of the equipment. If you are allergic to any of the materials used in this lab, alert me immediately.

In the spaces below, answer the following questions in full sentences:

1. What is your research question?

2. State your hypothesis. (Ex: If _____, then _____, because _____.)

3. Identify the following in your experiment:

- a. The independent variable: _____
(*what are you changing?*)

- b. The dependent variable: _____
(*what will change as the independent variable changes?*)

- c. All control variables: _____

(*what will NOT change?*)

4. List the materials you plan to use as you design your experiment.

5. In an experiment, qualitative data are descriptive traits and characteristics, and quantitative data are countable, measurable, and expressed with numbers. What data do you plan to collect during your experiment? Provide two qualitative and two quantitative traits you will observe and measure.

Qualitative Data Traits:

1. _____

2. _____

Quantitative Data Traits:

1. _____

2. _____

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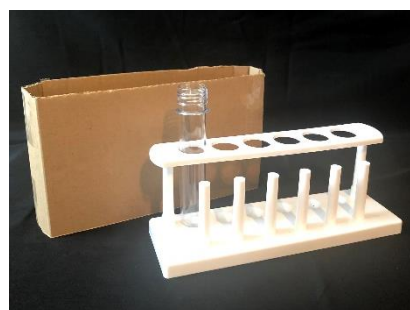
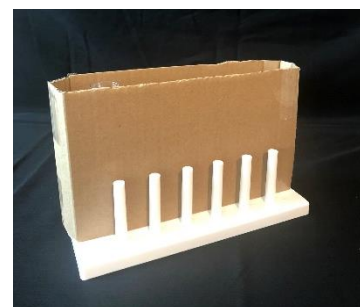
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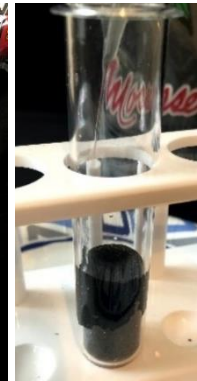


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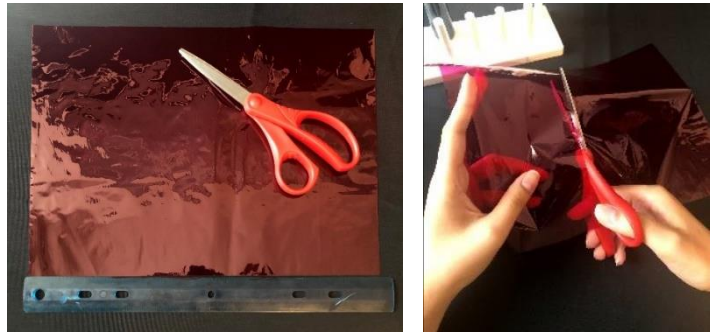
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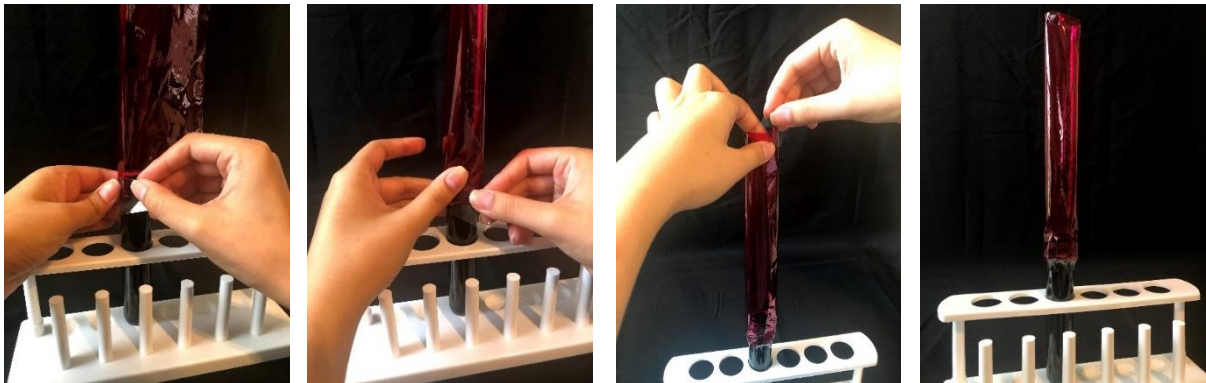
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Step 3: Repeat Step 2 for three experimental plants with COLORED cellophane, as well as three control plants with BLACK cellophane. Black cellophane acts as a control in this experiment, since it lowers the amount of light transmitted through to the plant but does not change the relative amounts of the different wavelengths of light. This enables the experiment to only focus on light color as an influence on plant growth, without the confounding effect of different amounts of light.

Student name: _____ Date: _____

Exploration Phase: Data Sheet

Quantitative Data: In the following tables, record the quantitative data you collect during your experiment. In the top row, label Trait 1 and Trait 2 with the two **quantitative** data traits you described in experimental design. Be sure to fill in your traits in the spaces provided for both the control and experimental tables. Throughout the experiment, fill in your measurements for each of the rows.

In the quantitative data tables, there are ‘Average’ boxes under each trait for each day. In this box, find and record the average measurements from the plants in the control and experimental treatments. *Calculate the average value for each quantitative trait, each day measurements are taken.*

Quantitative Data: Control Plants (Black Cellophane)

Time	Trait 1:			Trait 2:		
	Control Plant 1	Control Plant 2	Control Plant 3	Control Plant 1	Control Plant 2	Control Plant 3
1						
	Average:			Average:		
2						
	Average:			Average:		
3						
	Average:			Average:		

4						
	Average:			Average:		
5						
	Average:			Average:		
6						
	Average:			Average:		
7						
	Average:			Average:		
8						
	Average:			Average:		
9						
	Average:			Average:		
10						
	Average:			Average:		

Quantitative Data: Experimental Plants

(Cellophane Color: _____)

Time	Trait 1:			Trait 2:		
	Experimental Plant 1	Experimental Plant 2	Experimental Plant 3	Experimental Plant 1	Experimental Plant 2	Experimental Plant 3
1						
	Average:			Average:		
2						
	Average:			Average:		
3						
	Average:			Average:		
4						
	Average:			Average:		
5						
	Average:			Average:		
6						
	Average:			Average:		
7						
	Average:			Average:		
8						
	Average:			Average:		

9						
	Average:			Average:		
10						
	Average:			Average:		

Qualitative data: In the tables below, note any qualitative observations throughout the experiment. In the top row, there are spaces for you to label Trait 1 and Trait 2, using the **qualitative** data you described in your experimental design. Be sure to record your traits in the spaces provided for both the control and experimental tables. Throughout the experiment, note any observations or changes in your qualitative traits for each day. (Write 'N/A' for any day you do not observe changes)

Quantitative Data: Control Plants (Black Cellophane):

Time (days)	Trait 1:		Trait 2:	
1				
2				

3				
4				
5				
6				
7				
8				

9				
10				

Quantitative Data: Experimental Plants

(Cellophane Color: _____)

Time (days)	Trait 1:		Trait 2:	
1				
2				

3				
4				
5				
6				
7				
8				

9				
10				

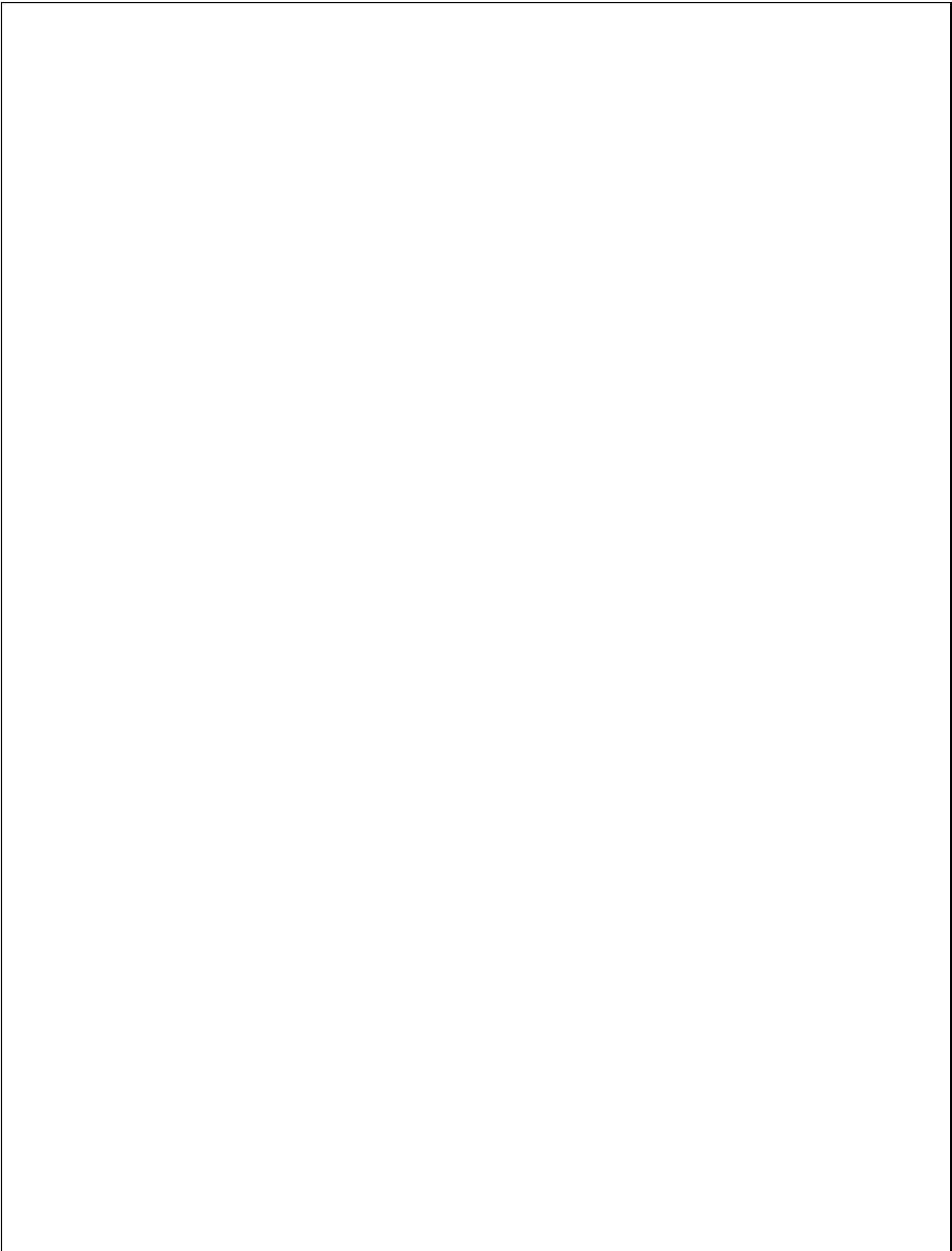
Student name: _____ Date: _____

Exploration Phase: Analysis of Experimental Data

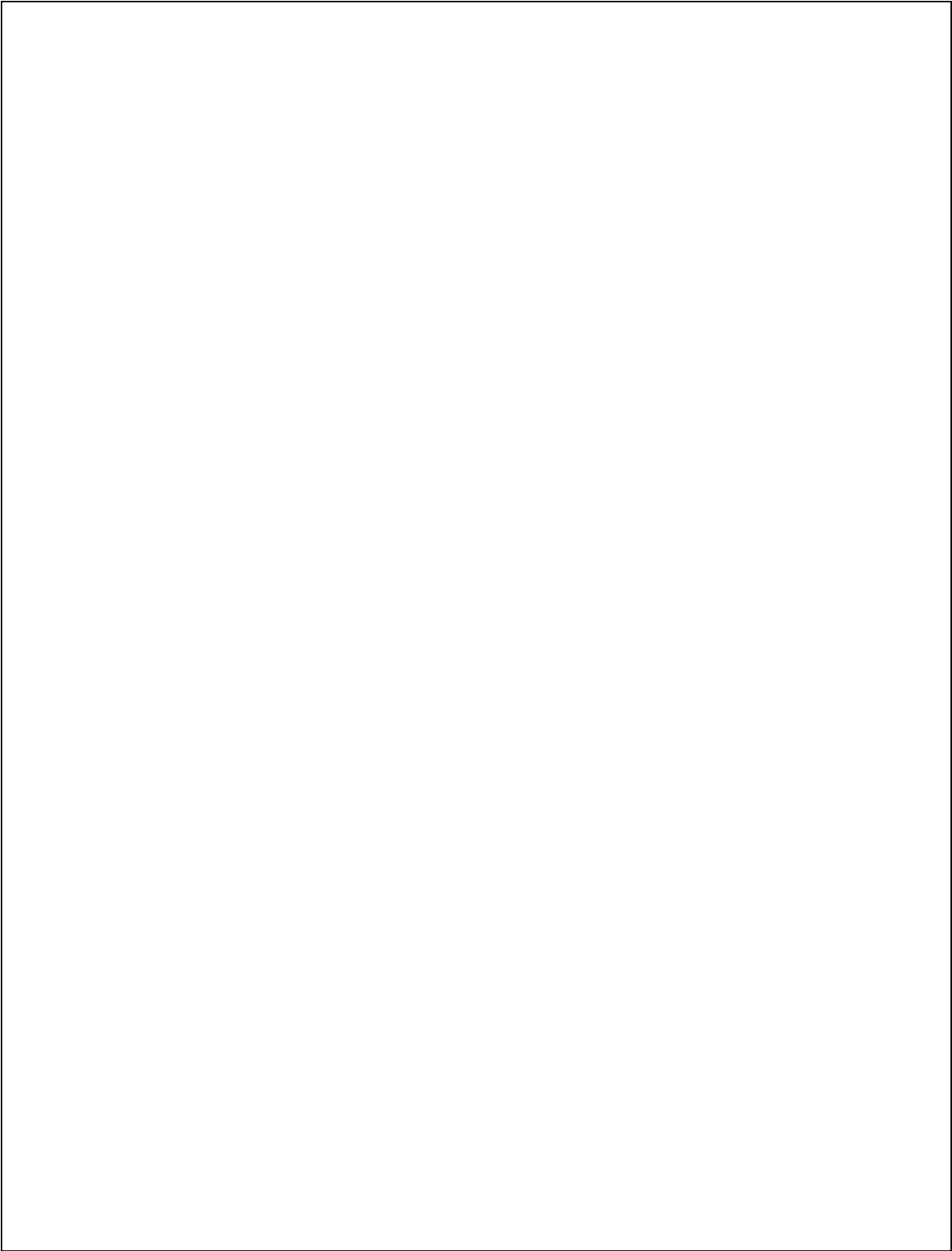
Qualitative Data: In the space below, write a summary of the qualitative observations you made over the course of the experimental testing period. What were the final results of your experiment? How did the qualitative data change over time? What are the qualitative differences between the plants grown under control and colored light environments? How do the final results of your experiment compare to your hypothesis?

Quantitative Data: Now that you have collected your data, collaborate with your group to develop graphs to represent your data. On the following pages, draw two graphs with properly marked increments, axes titles, and graph titles. Graph 1 should show Trait 1, and Graph 2 should show Trait 2. Use the average values you found for each day. If necessary, include a key for any symbols or colors you use to symbolize different sets of data.

Graph 1:



Graph 2:



Quick Assessment:

Jamie wants to test her claim that plants watered with distilled water will grow better than plants watered with rainwater. She grew five plants that she watered only with distilled water and five that she watered with rainwater. After allowing her experiment to run for ten days, she recorded her data in the graphs below: 1) Mean Number of Secondary Shoots and 2) Mean Plant Height. Was Jamie's claim correct? Provide evidence to support your answer.

