Module 1: Respiration
4th Grade

About the Instructions:

This document is intended for use by classroom teachers, SciTrek leads, and SciTrek volunteers. The document has been composed with input from teachers, leads, volunteers, and SciTrek staff to provide suggestions to future teachers/leads/volunteers. The instructions are not intended to be used as a direct script, but were written to provide teachers/leads/volunteers with a guideline to present the information that has worked in the past. Teachers/leads/volunteers should feel free to deviate from the instructions to help students reach the learning objectives of the module. Places in which you can be creative and mold the program to meet your individual teaching style, or to meet the needs of students in the class are: during class discussions, managing the groups/class, generating alternative examples, and asking students leading questions. However, while running the module make sure to cover all the material each day within the scheduled 60 minutes. In addition, no changes should be made to the academic language surrounding procedures or the Procedure Activity.

Activity Schedule:
Day 1 must be scheduled to allow the bottles for the initial observation to be brought to the classroom 24 hours prior to Day 1.
Day 4 must be scheduled to allow students to start their experiment 24 hours prior to Day 4. This is known as Day 3.5 in these instructions.

Day 1: Procedure Assessment/Observations/Variables (60 minutes)
Day 2: Question/Materials Page/Experimental Set-Up/Procedure Activity (60 minutes)
Day 3: Procedure Activity/Procedure/Results Table (60 minutes)
Day 3.5: Experiment (15 minutes)
Day 4: Experiment/Results Summary/Poster Making (60 minutes)
Day 5: Poster Presentations (60 minutes)
Day 6: Procedure Assessment/Tie to Standards (60 minutes)

The exact module dates and times are posted on the SciTrek website (http://www.chem.ucsb.edu/scitrek/elementary) under the school/teacher. The times on the website include transportation time to and from the SciTrek office (Chem 1105). Thirty minutes are allotted for transportation before and after the module, therefore, if a module was running from 10:00-11:00, then the module times on the website would be from 9:30-11:30.

Student Groups:

For the initial observation (Day 1), students work in three groups of ~ten students each. After Day 1, the groups of ~ten students are further subdivided into two subgroups, ~five students each, for the rest of the module. One volunteer is assigned to help each group (two subgroups). We find groups/subgroups work best when they are mixed levels and mixed language abilities.

NGSS Performance Expectation Addressed:

4-LS1-1 Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.
**Learning Objectives:**

1. Students will know that animals breathe in oxygen and breathe out carbon dioxide.
2. Students will know that plants take in carbon dioxide and release oxygen during photosynthesis.
3. Students will be able to annotate controls, changing variables, and/or data collection within a procedure.
4. Students will be able to determine if a statement could be a correct step for a procedure from a given question and experimental set-up.
5. Students will be able to list at least two ways that they behaved like scientists.

**Classroom Teacher Responsibilities:**

In order for SciTrek to be sustainable, the program needs to work with teachers on developing their abilities to run student-centered inquiry-based science lessons on their own in their classrooms. As teachers take over the role of SciTrek lead, SciTrek will expand to additional classrooms. Even when teachers lead the modules in their own classrooms, SciTrek will continue to provide volunteers and all of the materials needed to run the module. Below is a sample timeline for teachers to take over the role as the SciTrek lead.

*Groups are made up of ~ten students and are subdivided into two subgroups (~five students), after Day 1 of the module.

1. Year 1
   a. Classroom teacher leads a group (Role: Group Lead; this role is referred to as “volunteer” in these instructions)

2. Year 2
   a. Classroom teacher co-leads the modules with a SciTrek staff member (Role: Co-Lead)
      i. Classroom teacher will be responsible for leading entire class discussions (Ex: Procedure Activity).
      ii. Classroom teacher will be responsible for time management.
      iii. Classroom teacher will be responsible for overseeing volunteers and helping any groups that are struggling.
      iv. Classroom teacher will be responsible for all above activities, the SciTrek co-lead will only step in for emergencies.
      v. The SciTrek co-lead will run the Tie to Standards Activity.

3. Year 3 and beyond
   a. Classroom teacher leads the modules (Role: Lead)
      i. Classroom teacher will be responsible for leading entire class discussions (Ex: Procedure Activity).
      ii. Classroom teacher will be responsible for time management.
      iii. Classroom teacher will be responsible for overseeing volunteers and helping any groups that are struggling.
      iv. A SciTrek staff member will co-lead the Tie to Standards Activity with the classroom teacher for year 3.

SciTrek staff is counting on teacher involvement. Teachers should notify the SciTrek staff if they will not be present on any day(s) of the module. Additional steps can be taken to become a SciTrek lead faster than the proposed schedule above. Contact scitrekelementary@chem.ucsb.edu to learn more.

In addition, teachers are required to come to UCSB for the module orientation, approximately one week prior to the start of the module. Contact scitrekelementary@chem.ucsb.edu for exact times and dates, or see our website at http://www.chem.ucsb.edu/scitrek/elementary under your class’ module times. At the orientation, teachers will go over module content, learn their responsibilities during the module, and meet the volunteers that will be helping in their classroom. If you are not able to come to the orientation
at UCSB, you must complete an online orientation. Failure to complete an orientation for the module will result in loss of priority registration for next year.

Prior to the Module (at least 1 week):

1. Come to the SciTrek module orientation at UCSB.

During the Module:

If possible, have a document camera available to the SciTrek lead every day of the module. If you do not have a document camera, please tell the SciTrek staff at orientation.

Day 0:
24 hours before the SciTrek module starts, three sets of three bottles and a lamp (with 60 W equivalent LED bulb) will be brought to the classroom. Each set of bottles will contain: one bottle with only solution, one bottle with solution/aquatic snail, and one bottle with solution/aquatic plant. All of the bottles need to be under the provided light until the module starts the next day. When SciTrek brings the materials to your classroom, they will need 5 minutes to talk to the students to explain the contents and conditions of each bottle.

Day 1:
Have the students’ desks/tables moved into three groups and cleared off. This ensures that each student has a desk during SciTrek activities and that students can begin the module as soon as SciTrek arrives.

Days 2-4:
Have the students’ desks/tables moved into six groups and cleared off. This ensures that each student has a desk during SciTrek activities and that students can begin the module as soon as SciTrek arrives.

Day 3:
Confirm with the SciTrek lead when/where you will get the plants/animals to start the experiment. Have a spot in your classroom where five Xerox boxes can sit. These boxes must be near plugs so that the lamps, which sit on top of the boxes, can be plugged in (SciTrek will provide extension cords). These lamps need to be kept on from Day 3.5 until Day 4.

Day 3.5:
A SciTrek staff member will be present to help fill the experiment bottles.

Days 5-6:
Have the students’ desks/tables cleared off. The desks/tables do not need to be moved into groups.

Scheduling Alternatives:

Some teachers have expressed interest in giving the students more time to work with the volunteers throughout the module. Below are options that will allow the students more time to work with the volunteers. If you plan to do any of the following options, please inform the SciTrek staff no later than your orientation date (approximately one week before your module, exact orientation times are found at: http://www.chem.ucsb.edu/scitrek/elementary). This will allow the SciTrek staff to provide you with all needed materials.

Day 1:
If you would like to have more time for your students to make observations and generate variables, you can do the Procedure Assessment before SciTrek arrives.
Day 2:
If you would like to have more time for your students to design their experiments, you can do one or both of the following activities:
1) Example question and experimental set-up outlined in the introduction before SciTrek arrives.
2) The first part of the Procedure Activity after SciTrek leaves (pages 7 and 8, student notebook).

Day 3:
If you would like to have more time for your students to write their procedures, you can do the second part of the Procedure Activity (page 9, student notebook) before SciTrek arrives.

Day 4:
If you would like to have more time for your students to analyze their experiments and make posters, you can do the example results summary before SciTrek arrives.

Day 5:
If you would like to have more time for your students to discuss their experiments during poster presentations, you may take more time for each presentation and finish the presentations after SciTrek leaves.

Day 6:
If you would like more time for the Tie to Standards Activity, you may give the Procedure Assessment before SciTrek arrives.

Materials Used for this Module:

1. Bromothymol blue (Fisher part number 10273370 )
   Concentrated Solution
   1. Mix 0.1 g of bromothymol blue powder with 10 ml of 1.0 M sodium hydroxide.
   2. Add 20 ml of ethyl alcohol
   3. The solution should be deep blue
   4. Dilute with deionized water to 1 L
   Solution for Bottles:
   1. Remove 50 ml of water from a gallon bottle of distilled water. (Note: The water must be distilled. Drinking water cannot be used, or the experiment will not work.)
   2. Put 50 ml of concentrated bromothymol blue into the remaining water in the gallon bottle.
   3. Shake the solution of water and bromothymol blue.
   4. Pour solution into bottles and cap.
2. Small bottles [8 oz Clear PET French Square Bottle with 38/400 Neck (United States Plastic Corp.: Item 70346)]
3. Medium bottles [12 oz Clear PET French Square Bottle with 38/400 Neck (United States Plastic Corp.: Item 83597)]
4. Large bottles [16 oz Clear PET French Square Bottle with 38/400 Neck (United States Plastic Corp.: Item 70347)]
5. Extra-large bottles [32 oz Clear PET French Square Bottle with 38/400 Neck (United States Plastic Corp.: Item 70348)]
6. Bottle caps [38/400 Red Polypropylene Unlined Ribbed Cap (United States Plastic Corp.: Item 68751)]
7. Mystery snails
8. African frogs
9. Mosquito fish
10. Algae Shrimp
11. Plant 1: Ludwigia
12. Plant 2: Hornswort
13. Plant 3: Anacharis
14. Plant 4: Wisteria
15. Tree leaves: Any two tree leaves should work. Do not use poisonous tree leaves.
16. Flowers: Daisy and Carnation
17. Individual Plant Light (Carolina Biological Supply Company part number: 666900)
18. Light bulbs (60 W equivalent LED (800 lumen) light bulbs) (Philips part number: 046677455507) (Make sure that you use LED light bulbs because these give off less heat than incandescent bulbs. If you use incandescent bulbs you will kill all of the animals.)
19. Extension cord
20. Boxes for different amounts of light are handmade by taking a Xerox box and cutting a 11.5 cm diameter hole in the top of the box (when the box is on its side) and taping on a 13 cm x 14 cm polarizing filter over the hole (Educational Innovations part number: PF-12). The different amounts of light are then made by having the 60 W equivalent LED light bulb go through: one filter (level 4), two filters that are aligned (level 3), two filters that are 45° to each other (level 2), and two filters that are 75° to each other (level 1). All filters are taped to the top of the box so that they will not move. Another Xerox box is available with no holes to provide a dark environment (level 0). A picture of one of the boxes is shown below.

All printed materials used by SciTrek (student notebooks, materials page, lead picture packet, poster parts, instructions, and nametags) can be made available for use and/or editing by emailing scitrekelementary@chem.ucsb.edu.

Types of Documents:

Student Notebook:
One given to every student and is filled out by the student. In these instructions, the examples are rectangular and filled out in black. The lead will use a student notebook to write in as an example for students. The notebook that the lead uses is referred to as the class notebook in these instructions.

Notepad:
One given to every group and is filled out by the volunteer. In these instructions, the examples are squarer and filled out in blue.

Picture Packet:
One per class that, if needed, the lead fills out. In these instructions, the examples are rectangular, labeled, and, if applicable, filled out in blue.

In these instructions, all other example documents are labeled.
Day 1: Procedure Assessment/Observations/Variables

Schedule:

Introduction (SciTrek Lead) – 2 minutes
Procedure Assessment (SciTrek Lead) – 10 minutes
Observation Discussion (SciTrek Lead) – 4 minutes
Observations (SciTrek Volunteers) – 14 minutes
Variable Discussion (SciTrek Lead) – 8 minutes
Variables (SciTrek Volunteers) – 19 minutes
Wrap-Up (SciTrek Lead) – 3 minutes

Materials:

(3) Volunteer Boxes:
- □ Student nametags
- □ (12) Student notebooks
- □ Volunteer instructions
- □ Volunteer lab coat
- □ (2) Pencils
- □ (2) Wet erase markers

(3) Supplies Already in Classroom:
- □ (3) Bottles with solution (labeled “Bottle 1”)
- □ (3) Bottles with solution and an aquatic snail (labeled “Bottle 2”)
- □ (3) Bottles with solution and an aquatic plant (labeled “Bottle 3”)

Other Supplies:
- □ (3) Large group notepads

Lead Box:
- □ (3) Blank nametags
- □ (3) Extra student notebooks
- □ Lead instructions
- □ Respiration picture packet
- □ Lead lab coat
- □ (35) Procedure Assessments
- □ Time card
- □ (2) Pencils
- □ (2) Wet erase markers
- □ (3) Markers (orange, blue, green)
- □ Straw
- □ (9) Caps without holes
### OBSERVATIONS

**Contents:** Materials that are inside of the bottle besides the solution.
- Ex: Aquatic Plant

**Conditions:** Other variables inside of the bottle that may affect the solution.
- Ex: In the Dark

<table>
<thead>
<tr>
<th>Bottle 1</th>
<th>Bottle 2</th>
<th>Bottle 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contents:</td>
<td>None</td>
<td>Aquatic Snail</td>
</tr>
<tr>
<td>Conditions:</td>
<td>24 hours under light</td>
<td>Blue</td>
</tr>
<tr>
<td>Color of Solution at Start of Experiment:</td>
<td>Blue</td>
<td>Blue</td>
</tr>
<tr>
<td>Color of Solution at End of Experiment:</td>
<td>Blue</td>
<td>Yellow</td>
</tr>
</tbody>
</table>

Describe what happened to the solution over the course of 24 hours:

- **Bottle 1:** The solution with nothing started as blue, and after 24 hours was blue.
- **Bottle 2:** The solution with an aquatic snail started as blue, and after 24 hours was yellow.
- **Bottle 3:** The solution with an aquatic plant started as blue, and after 24 hours was blue.

### VARIABLES

<table>
<thead>
<tr>
<th>Variable</th>
<th>How will changing this variable affect the color of the solution?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Animal Type</td>
<td>Animals will make the solution turn yellow.</td>
</tr>
<tr>
<td>Plant Type</td>
<td>Plants will make the solution stay blue.</td>
</tr>
<tr>
<td>Light Amount</td>
<td>The dark will make the solution more blue than the light.</td>
</tr>
<tr>
<td>Bottle Size</td>
<td>Larger bottles will make the solution more blue.</td>
</tr>
<tr>
<td>Number of Animals</td>
<td>More animals will make the solution turn more yellow than one animal.</td>
</tr>
</tbody>
</table>
Preparation:

SciTrek Lead:
1. Make sure volunteers are passing out nametags.
2. Make sure volunteers are setting up for the initial observation.
3. If the classroom has a document camera, ask the teacher to use it to show the initial bottle picture (page 1, picture packet) and class question (front cover, student notebook). If the classroom does not have a document camera, then write the class question on the front board during the Variable Discussion.
4. Pass out the Procedure Assessments.

SciTrek Volunteers:
1. Pass out nametags.
   a. You may need to do this during the Introduction/Procedure Assessment. Quietly set each student’s nametag on their desk without talking to them. You will know their name because it will be on their assessment. If you cannot find a student, ask the classroom teacher or lead when they are not talking with the class.
2. Assemble the experimental set-up (shown in picture below).
   a. Get bottles 1-3 for your group (under lamp in classroom) and have them ready to put on the table once your students come to your group.

Introduction:
(2 minutes – Full Class – SciTrek Lead)

For UCSB Lead:
“Hi, we are scientists from UCSB and we want to show you what we do as scientists. We will show you an experiment and then you can make observations, come up with a class question, and design your own experiment to help answer the class question. We want to show you that you can do science and have fun.”

For Teacher Lead:
“I have asked some scientists from UCSB to come and help us with a long-term science investigation. We will make observations, come up with a class question, and you will design your own experiment to help answer the class question.”

Allow the UCSB volunteers to introduce themselves and share their majors.
**Procedure Assessment:**
(10 minutes – Full Class – SciTrek Lead)

“Before we start with the module, we will determine how your ideas on procedures are developing.” Have students write their name, teacher’s name, and date at the top of the assessment. Tell students, “When doing this assessment, you should work individually so there should be no talking.” As you are giving the assessment, walk around the room and verify that students have written their name on their assessment.

Read the question, changing variable (Ex: the changing variable was solid amount), and controls (Ex: the controls were liquid type, time, container type…). You do not need to read the values of the changing variable or the controls. Then, read the directions to the students. Read each of the statements and have students underline controls/circle changing variables/box data collection before circling if the statement could be an appropriate procedure step. When students are finished, collect the assessments and verify that students’ names are on them.

**Observation Discussion:**
(4 minutes – Full Class – SciTrek Lead)

Tell students, “Scientists make many observations.” Ask the class, “What is an observation? What are the types of things that you can record for an observation?” If they have trouble, show them an object and let them make some observations. Turn these specific observations into general features of an observation. Examples of possible general observations are: color, texture, size, weight, temperature, etc. Lead students to understand that an observation is a description using your five senses.

Tell students, “In this experiment we are going to use two terms to help us make observations: contents and conditions. Contents are defined as the materials that are inside the bottle besides the solution.” Hold up one of the bottles and ask students, “What are the contents in this bottle?” Possible student response: an aquatic plant. “Conditions are defined as other variables outside of the bottle that may affect the solution.” Ask students, “What are the conditions of the bottles?” Students should reply, “Under light for 24 hours and at room temperature.”

Tell the class, “You will now get in your groups and make observations. To determine your group, you will need to look at the color of your nametag (orange, blue, or green).” Tell each colored group where to go and to bring a pencil.

If a student does not have a nametag, identify the group with the least number of students in it and write the student’s name on one of the extra nametags that are in the lead box using that color of marker.

As students are going to their groups, put the initial bottle picture (page 1, picture packet) under the document camera. If the classroom teacher took a picture of their bottles, use that picture instead.
**Observations:**
*(14 minutes – Groups – SciTrek Volunteers)*

Once students come over to your group, have them sit in boy/girl fashion. Verify the table is set up as described in the Set-Up Section. A picture of the bottles from 24 hours earlier will be on the document camera (see example above). Pass out a notebook to each student. Have students write their name, teacher’s name, group color, and your name (volunteer’s name) on the front cover of their notebooks. Students will leave the subgroup number and class question blank. Then have students turn to page 2 of their notebook.

As a group, have the students fill in the table describing the bottle contents and conditions, as well as the color of the solution before and after the 24 hours. While you are recording their answers on the group notepad, have students fill in the table in their notebook.

Ask students, “What happened to the solutions over the course of 24 hours?” If needed, probe students with questions such as:
- What is the biggest difference that you see between the solutions?
- How are the solutions different from 24 hours ago?

By the end of the discussion make sure that students understand that over the course of 24 hours the bottle with the aquatic snail as its contents caused the solution to turn yellow while the bottle with no contents and the bottle with the aquatic plant as contents caused the solution to remain blue. Some groups might notice that the solution that had an aquatic plant is a little lighter blue than the original bottle; you can record this on the table. Have students write one summary sentence about what happened to the solution in each bottle. If students are struggling, write the following sentence frame on the group notepad: The solution with _____ started as _____ and after 24 hours ______.

If there is additional time, have students generate a few more general observations about the bottles/solutions.

An example filled out initial observations is shown below.
**Variable Discussion:**

*(8 minutes – Full Class – SciTrek Lead)*

Ask the class questions to review the experiment that they carried out as well as what they learned. Make sure by the end of the discussion, students have identified that the solution color in the bottle with no contents stayed blue, the solution color in the bottle with the aquatic plant stayed blue (or turned slightly green), and the solution color in the bottle with the snail turned yellow.

Ask the class, “What was the most interesting observation from the experiment?” Possible student response: the solution in the bottle with the aquatic snail turned from blue to yellow. Tell the class, “We will now work together to answer the question, ‘What variables affect the color of the solution?’” Write this question on the front page of the class notebook under the document camera and have students copy this question onto their notebooks.

Ask students the following questions:

- What does the word “variable” mean to a scientist?  
  (variables are the parts of the experiment that you can change)
- What was the changing variable in the experiment that we just did?  
  (contents of the bottle)
- Do you think that there are multiple variables that will affect the solution color?  
  (multiple variables might affect the solution color)
- Explain that this is why we will need to work as a class to answer the class question: “What variables affect the color of the solution?”

Tell the class, “You are going to think about variables in the experiment that you could change to help us answer the class question. In addition to generating variables, you should think about how these variables might affect the outcome of the experiment.” Ask the class, “What do you think is a variable that might affect the color of the solution?” Then, have them tell you how they think that variable would affect the
color of the solution. Probe them on how they would design an experiment to test if this variable affected the solution color. Finally, have the students make a prediction of the results for the experiment they proposed. Remind students, “Predictions can be wrong, and we will not know the correct answers until we carry out the experiment.”

**Ex:**  
**Variable:** animal type  
*Why might this variable affect the solution color?* The snail turned the color of the solution yellow, so maybe all animals will have the same effect.  
*How would you test this variable?* Get bottles with blue solution and put different animals in each of the bottles.  
*Prediction:* All solutions will turn yellow because the color change is caused by something that all animals are producing.

Tell students, “You will now generate more variables and analyze them in your groups.”

**Variables:**  
*(19 minutes – Groups – SciTrek Volunteers)*

As a group, generate a variable and make a prediction about how it will affect the solution color. Encourage and challenge students to explain why they think their prediction is correct and how this variable will affect the solution color. If needed, you can write down a sentence frame for students to use. Repeat this process three more times, record these ideas on the group notepad, and have students copy them into their notebooks. If students have different predictions, they can write their own predictions in their notebooks. Next, students will individually generate at least one additional variable, make a prediction about how different values of this variable will affect the solution color, and record their ideas in their notebooks. Have students share these ideas with the group.

Prepare one student to share a variable and why they think it will affect the solution color during the class discussion.

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</table>
Wrap-Up:
(3 minutes – Full Class – SciTrek Lead)

Have one student from each group share a variable that they generated and how they think it will affect the solution color. Make sure that students tell you their predictions about how different values of that variable will affect the solution color.

Tell students, “Next session, you will design an experiment to answer the class question: What variables affect the color of the solution?”

Clean-Up:

1. Collect notebooks with attached nametags.
2. Replace the caps with holes with caps without holes on the bottles.
3. Place all materials into your group box and bring materials back to UCSB.

Day 2: Question/Materials Page/Experimental Set-Up/Procedure Activity

Schedule:

Introduction (SciTrek Lead) – 12 minutes
Question (SciTrek Volunteers) – 5 minutes
Materials Page (SciTrek Volunteers) – 5 minutes
Experimental Set-Up (SciTrek Volunteers) – 10 minutes
Procedure Activity (SciTrek Lead) – 26 minutes
Wrap-Up (SciTrek Lead) – 2 minutes

Materials:

(3) Volunteer Boxes:

☐ Student nametags ☐ Volunteer lab coat ☐ (2) Pencils
☐ Student notebooks ☐ (2) Materials pages (subgroup color & number indicated) ☐ (2) Red pens
☐ Volunteer instructions ☐ Notepad

Lead Box:

☐ (3) Blank nametags ☐ (3) Materials pages ☐ (2) Wet erase markers
☐ (3) Extra student notebooks ☐ Time card ☐ (3) Markers (orange, blue, green)
☐ Lead instructions ☐ (2) Pencils ☐ (2) Red pens
☐ Respiration picture packet ☐ Notepad
☐ Lead lab coat
Experimental Considerations:
1. You will have access to the materials on the materials page.
2. The liquid must remain the original solution.
3. You cannot design an experiment that you know will disturb an animal.
4. Only one animal per bottle.
5. You will only get four bottles containing original solution per group.

Changing Variable (Independent Variable): Light Amount

Discuss with your subgroup how you think your changing variable will affect the color of the solution.

QUESTION

Question our subgroup will investigate:
- If we change the light amount, what will happen to the color of the solution?

SciTrek Member Approval: SL

Get a materials page from your SciTrek volunteer and fill it out before moving onto the experimental set-up.

EXPERIMENTAL SET-UP

Write your changing variable (Ex: animal type) and the values (Ex: fish) for your trials under each bottle.

Changing Variable:

<table>
<thead>
<tr>
<th>Level 0</th>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>(no light)</td>
<td>(full light)</td>
<td>(no light)</td>
<td>(full light)</td>
</tr>
</tbody>
</table>

Controls (variables you will hold constant):
- Solution Type / Original
- Animal Type / No Animals
- Bottle Size / Small
- Time / 24 Hours
- Plant Type / Aquatic
- Cup Statement / On

SciTrek Member Approval: SL

SCIENTIFIC PRACTICES

Procedure

Directions: Fill in the missing definitions.

- Procedure: a set of steps to conduct an experiment.
- A complete procedure MUST have:
  - All values of the controls and the changing variable (dependent variable).
  - What data will be collected (measurements/observations).
  - The steps listed in order that they will be completed.
  - A complete procedure MUST NEVER have:
    - Extra or irrelevant information.
    - Opinions about the experiment.
    - Incorrect values of controls or the changing variable.

EXPERIMENTAL SET-UP

Changing Variable: Temperature

<table>
<thead>
<tr>
<th>Trial A</th>
<th>Trial B</th>
<th>Trial C</th>
<th>Trial D</th>
</tr>
</thead>
<tbody>
<tr>
<td>30°C</td>
<td>40°C</td>
<td>50°C</td>
<td>60°C</td>
</tr>
</tbody>
</table>

Controls (variables you will hold constant):
- Bat Size / Number
- Bat Circumference / cm
- Release Height / m
- Ground Type / Cement
- Ball Size / g
- Ball Release / Step

Directions:
Step 1: Make a hypothesis statement and underline controls, circles changing variables, and box information about data collected.
Step 2: Circle yes if the statement could be a correct step for a procedure about the question and experimental set-up above. If not, circle no.

- Get four (or more) rubber bands with circumferences of 8 cm.
- Heat rubber bands to temperatures of 110°C, 100°C, 90°C, 80°C.
- Measure and record.
- Heat bat (8 cm)
- Heat rubber bands to temperatures of 110°C, 100°C, 90°C, 80°C.
- Measure and record.
- Place rubber bands in water.
- Change the boiling point of the water.

Underline controls, circle changing variables, and box data collection.
Preparation:

SciTrek Lead:
1. Make sure volunteers are setting out notebooks to allow students within the same subgroup to work together.
2. If the classroom has a document camera, ask the teacher to use it to show the Day 1 final bottles picture (page 2, picture packet), question (page 4, student notebook), lead materials page (page 3, picture packet), experimental plants pictures (page 4, picture packet), experimental set-up (page 5, student notebook) and Procedure Activity (pages 7-8, student notebook). If the classroom does not have a document camera, then tape the poster-size notebook pages to the front board.

SciTrek Volunteers:
1. Set out notebooks/nametags to allow students in the same subgroup (same number on front of notebook) to work together.
2. Make sure you have two materials pages, each filled out with a subgroup number (1 or 2) and your group’s color to give to subgroups after they complete their question.
3. Have a red pen available to approve students’ question and experimental set-up (pages 4 and 5).

Note: Set notebooks where students will sit during the module even if another student is currently at that desk. If needed, students will move to these spots after the Introduction.

Introduction:
(12 minutes – Full Class – SciTrek Lead)

If students are not in their subgroups, tell them, “A notebook will be put on your desk, which is not your notebook and you should not move it. You will move to your notebook after the Introduction.”

Ask students, “What did we do and learn during our last meeting?” Then show them the picture of the bottles after 24 hours (page 2, picture packet) to help remind them. Possible student response: we observed what happened to the color of solution in bottles over the course of 24 hours. The solution stayed blue in the bottles containing only solution and solution with an aquatic plant. The solution turned yellow in the bottle containing solution with an aquatic snail. Ask the class, “What is the class question we will be investigating?” Students should reply, “What variables affect the color of the solution?”

Page 2, Picture Packet
Tell students, “One-way scientists answer questions is by performing experiments; today you will design an experiment to help answer the class question.” Ask the class, “Do you think there are multiple variables that could affect the solution’s color?” Possible student response: there are probably multiple variables.

Explain to students, “Many times when there is a large question, like our class question, scientists break it down into smaller questions that small groups of scientists can investigate, and then they compile their work to answer the large question. Therefore, each subgroup is going to generate a smaller question about one changing variable to investigate. Once we put all the subgroups’ research together, we should be able to answer the class question.”

Subgroups will first generate a question based on the changing variable that they plan to explore. They will then fill out their materials page, which will allow them to determine their experimental set-up. Tell students, “You will need to keep a few things in mind while you are going through this process.”

Experimental Considerations:
1. You will only have access to the materials on the materials page.
2. The liquid must remain the original solution.
3. You cannot design an experiment that you know will kill/hurt an animal.
4. Only one animal per bottle.
5. You will only get four bottles (containing original solution) per experiment.

Tell students, “We are now going to generate a class research question/experimental set-up together. I will write it in the class notebook so that you will be able to refer back to it when you are completing the process yourselves.” Make sure that students DO NOT fill out the class question/experimental set-up in their notebooks.

Tell students, “We first need to decide what the changing variable will be for the class experiment.” Ask students, “What are some of the variables you discussed last meeting?” Make a list of them on the board. Make sure “animal type” is one of the variables on the list. Ask students, “Which variable are you most interested in?” Most, if not all, students will say animal type. Tell students, “Since everyone is interested in animal type, this is what we will investigate as a class. Therefore, when you design an experiment with your subgroup, you will need to pick a variable other than animal type to investigate. This will allow us to have a wide range of variables tested, making poster day more interesting.” Record “animal type” for the changing variable in the class notebook (page 4) under the document camera.

Show students how to insert the changing variable and what they plan to measure/observe into the question frame to find the question that will be investigated, “If we change the animal type, what will happen to the color of the solution?”
Tell students, “Once you have determined your question and have approval, your SciTrek volunteer will give you a materials page for determining the values of your changing variable and controls.” Ask students, “What is a control?” Make sure that by the end of the conversation students understand that controls are variables that are held constant during an experiment. For example, if the caps were on all of the bottles, then one of their controls would be cap placement. These controls and control values can be different from the original experiment that they conducted on Day 1, but must remain constant throughout all the trials that they do for this experiment.

Show students the lead materials page (page 3, picture packet) and read the first step (For each bolded word, underline if it is a control and circle if it is a changing variable.). Then, have students tell you what to do for each bolded word. Read steps 2 and 3 on the materials page (For variables that are controls, choose 1 value. For the variable that is the changing variable, choose 4 values and write the trial letter next to each value.). Tell students, “You must also pay attention to notes on the material page about restrictions in materials.” Go through the remaining items on the materials page. Have them decide the values for the changing variable and controls, making sure to write the trial letter next to the changing variable values. After each control and/or changing variable value is selected, assign it to one student to remember so that they can share it out when you are filling in the materials page.

When selecting the value for plant type, show students the experimental plant pictures (page 4, picture packet). Lead students to understand that it will be difficult to determine what is affecting the color of the solution if we use both plants and animals; then try to get students to choose no plants.

When selecting the value for light amount, tell students, “Light amount is changed by having light go into a box with a filter. Therefore, unless you pick full light (level 5), you will not be able to see the animals.” Most classes will pick full light.
Tell students, “Once you have completed your materials page, you will fill out your experimental set-up (page 5, student notebook). First, you will fill out the information on the changing variable.” Ask students, “What is the changing variable for our class experiment, and what values did we select?” Then, fill in the values for all of the trials. Tell them, “Second, you will fill in information about the controls.” Ask students, “What is one of our controls and its value for the class experiment?” Show students how to record the control on the left side of the slash (Ex: plant type) and the value of that control on the right side of the slash (Ex: no plants). There are four possible variables to choose from on the materials page. Subgroups will be left with two control blanks empty after putting in the information from the materials page. Since all control blanks must be filled out, tell students, “You need to generate two additional variables that do not come from the materials page.” Lead students to realize these should be time/24 hours and cap placement/on.
Ask students, “Should everyone choose the same changing variable and why?” Possible student response: no, because we will not learn as much about the class question. Tell students, “This means you should try to explore a changing variable that you think no other subgroups are exploring. Remember, because we are exploring animal type as a class, you will not be able to change this variable, and the only animals you will have access to are snails. Therefore, you will get a slightly modified materials page. Once your subgroup has completed your experimental set-up, you should raise your hands and get it approved by your volunteer.” Above is an example of what should be filled out for the experimental set-up in the class notebook.

If needed, have students move into their subgroups. Place the class example question (page 4, student notebook) under the document camera so students may refer back to it as they design their experiments. As subgroups move onto their materials page, put the plant pictures (page 4, picture packet) under the document camera so that students can refer to it as they choose their materials. As subgroups move onto their experimental set-up, put the class experimental set-up (page 5, class notebook) under the document camera.

**Question:**
*(5 minutes – Subgroups – SciTrek Volunteers)*

Have subgroups decide what changing variable they want to explore for their experiment. Encourage your subgroups to have different changing variables. The lead will help coordinate between groups to ensure there is a variety of changing variables.

Each subgroup should briefly discuss how they think their changing variable will affect the solution’s color.

After subgroups have decided on their changing variable, have them fill out their question. When you sign off on their question, give them a materials page with their subgroup color and number designated in the upper right-hand corner. An example filled out question is shown below.
Materials Page:
(5 minutes – Subgroups – SciTrek Volunteers)

Have subgroups underline their controls and circle their changing variable on the materials page. Then, have them use the materials page to determine the values for their controls and changing variable. For the changing variable values, have students write the trial letter (A, B, C, D) next to the value they select. Ask students, “Why did you choose the values you did for your controls and changing variable?, Will these values make it easier or harder to answer your question?”

Make sure students have not gone over the maximum number of any of the items on the materials page. An example filled out materials page is shown in the Experimental Set-Up Section below (left).

Experimental Set-Up:
(10 minutes – Subgroups – SciTrek Volunteers)

Have subgroups use their materials page to fill in their experimental set-ups on page 5 of their notebooks. There will be two control blanks that will not come from the materials page, students should put time/24 hours and cap placement/on. When you sign off on their experimental set-up, collect the materials page and verify that it is filled out correctly and completely. Filling out the materials page is essential for students to obtain the correct materials for their experiments on Day 3.5. An example filled out experimental set-up is shown below (right).
Tell students, “I have heard some great experiments being designed and I am excited to see the outcomes of your experiments. Now that you have determined your experimental set-up, you are going to need to write a procedure. But before you write your own procedures, it is necessary that you know what information a procedure contains and what information should not be included.” Have students turn to page 7 of their notebooks while you put page 7 of class notebook under the document camera.

Ask the class, “What is a procedure?” After listening to the students’ answers make sure that the students understand that a procedure is a set of steps to conduct an experiment. Write this definition on page 7 of the class notebook for the students to copy.

Tell students, “In order to write a procedure, we need to make sure that we understand what information MUST be included in a procedure.” Ask students, “What information do you think should be included in a procedure?” Make sure that students generate the following three items: 1) all values of the controls and the changing variable (independent variable), 2) what data will be collected (dependent variable), and 3) the steps listed in the order that they will be completed. If students are having trouble generating these ideas, have them think back to the information that they put into their question and experimental set-up. Once students have generated these ideas, have them fill in the blanks in their notebooks with the underlined words above while you fill in the values in the class notebook. Tell students, “To help us recognize control values, changing variable values, and data collection information in procedural steps, we will underline information about controls, circle information about changing variables, and box information about data collection.” On the class notebook, underline the word controls, circle the words changing variable, and box the word data.

Tell students, “We also need to discuss items that MUST NEVER be included in a procedure.” Ask students, “What information do you think should not be included in a procedure?” Make sure that...
students generate the following three items: 1) extra or irrelevant information, 2) opinions about the experiment, and 3) incorrect values of controls or the changing variable. Have students fill in the blanks in their notebooks with the underlined words above while you fill in the values in the class notebook.

**Note:** If students need help understanding what it means to have opinions or irrelevant information in a procedure, you can give them the following example: a scientist was designing an experiment to test which laundry detergent will have the largest reduction in the size of grass stains on cotton. Below are examples of steps containing an opinion and irrelevant information:

- **Step with an Opinion:** Get three brands of good smelling laundry detergent A) Tide, B) Gain, C) All.
- **Step with Irrelevant Information:** Put on cotton pants and play soccer in them until you get a grass stain.

Have students turn to page 8 in their notebooks while you put page 8 of the class notebook under the document camera. Tell students, “We are now going to look at a group of scientists’ question and experimental set-up and we will then decide if the following seven statements would be appropriate procedural steps for those scientists’ experiment. These steps are not meant to be a full procedure and are therefore not in any order. We are just trying to determine if they could be correct steps in a procedure for this experiment.” Go over the question, changing variable, changing variable values, controls, and control values with the students.

Tell students, “The first thing you should do when looking at a possible procedural step is identify the information within that statement. You will do this by underlining any information about controls, circling information about the changing variable, and boxing information about data collection.” To practice, have students look at the question on page 8 and tell you what should be underlined, circled, or boxed. Within the question, students should circle “ball temperature” and box “height the ball bounces.” Once they have determined what information is in the step, they will have to check if the statement could be a possible procedural step by looking at the information in the question and experimental set-up. If the
statement could be a possible procedural step, they will circle “yes,” if not, they will circle “no.” Tell students, “We will now go over all of the statements together.”

Below are the explanations and answers to numbers 1-7 on page 8.

**Number 1:** Get four 623 g rubber balls with circumferences of 88 cm.

*Correct – Step with Controls Only*

- What should be underlined, circled, and/or boxed? “623 g”, “rubber”, and “88 cm” should be underlined.
- Are there any opinions, incorrect, or extra/irrelevant information in this statement? No.
- What is this step about? This step is about the ball that will be used in the experiment.
- Is there any other information that should have been included in this step? No.
- Could this be a correct procedural step? Yes (have students circle “yes”).

**Number 2:** Heat rubber balls to temperatures of A) 30°C, B) 40°C, C) 50°C, D) 60°C.

*Correct – Changing Variable with Values*

- What should be underlined, circled, and/or boxed? “Rubber” should be underlined and “A) 30°C, B) 40°C, C) 50°C, D) 60°C” should be circled.
- Are there any opinions, incorrect, or extra/irrelevant information in this statement? No.
- What is this step about? This step is about getting each ball ready to be bounced by heating them.
- Is there any other information that should have been included in this step? No. Students may bring up that the ball is not fully described. If they do, ask them, “Could the ball have been described in a previous step?” Since the answer is yes this does not need to be included.
- Could this be a correct procedural step? Yes (have students circle “yes”).

**Number 3:** Measure and observe.

*Incorrect – Vague Data Collection*

- What should be underlined, circled, and/or boxed? “Measure and observe” should be boxed.
- Are there any opinions, incorrect, or extra/irrelevant information in this statement? No.
- What is this step about? This step is about data collection.
- Is there any other information that should have been included in this step? Yes, this step does not include what data will be collected. Ask students, “What data should be collected to answer the scientists’ question?” Students should reply, “The height the ball bounces.”
- Could this be a correct procedural step? No (have students circle “no”).
**Number 4:** Heat ball C to 50°C.

**Correct – One Changing Variable Value Explained**

What should be underlined, circled, and/or boxed?

“50°C” should be circled.

Are there any opinions, incorrect, or extra/irrelevant information in this statement?

No.

What is this step about?

Getting ball C ready to be bounced by heating it.

Is there any other information that should have been included in this step?

No. Students may bring up that only one changing variable value is listed. Ask students, “Could the rest of the values have been listed in other steps?” They should answer yes, therefore, this information does not need to be included.

Could this be a correct procedural step?

Yes (have students circle “yes”).

**Number 5:** Heat rubber balls to different ball temperatures.

**Incorrect – Changing Variable with No Values**

What should be underlined, circled, and/or boxed?

“Rubber” should be underlined and “ball temperatures” should be circled.

Are there any opinions, incorrect, or extra/irrelevant information in this statement?

No.

What is this step about?

Getting each ball ready to be bounced by heating them.

Is there any other information that should have been included in this step?

Yes, this step does not include the temperature the balls should be heated to. Since this information is missing, scientists who attempt to perform this experiment may use different temperatures from one another.

Could this be a correct procedural step?

No (have students circle “no”).

**Number 6:** Measure how high each ball bounces on the cement.

**Correct – Measurement**

What should be underlined, circled, and/or boxed?

“Cement” should be underlined and “measure how high each ball bounces” should be boxed.

Are there any opinions, incorrect, or extra/irrelevant information in this statement?

No.

What is this step about?

This step is about data collection.

Is there any other information that should have been included in this step?

No. The step is about data collection and includes what data will be collected.

Could this be a correct procedural step?

Yes (have students circle “yes”).

**Number 7:** Drop the boring ball from a height of 3 m.

**Incorrect – Opinion during Experiment**

What should be underlined, circled, and/or boxed?

“Drop” and “3 m” should be underlined.

Are there any opinions, incorrect, or extra/irrelevant information in this statement?

Yes, the word boring is an opinion and should not be included in a procedure.

Could this be a correct procedural step?

No (have the students circle “no”).
Tell students, “Next session, you will write a procedure for your experiment. All of your experiments will help us answer the class question: What variables affect the color of the solution?”

Clean-Up:

1. Collect notebooks with attached nametags.
2. Place all materials into your group box and bring materials back to UCSB.

Day 3: Procedure Activity/Procedure/Results Table

Schedule:

Introduction (SciTrek Lead) – 3 minutes
Procedure Activity (SciTrek Lead) – 15 minutes
Procedure Discussion/Procedure (SciTrek Lead/SciTrek Volunteers) – 35 minutes
Results Table (SciTrek Volunteers) – 5 minutes
Wrap-Up (SciTrek Lead) – 2 minutes

Materials:

(3) Volunteer Boxes:
- ☐ Student nametags
- ☐ Student notebooks
- ☐ Volunteer instructions

- ☐ Volunteer lab coat
- ☐ (2) Red pens
- ☐ Notepad

- ☐ (2) Pencils

- ☐ (2) Pencils
Other Supplies:

- ☐ 28 Labeled bottles (with group color, number, and trial letter) including class experiment bottles divided in two buckets
- ☐ 7 Extra Bottles (1XL, 1L, 1M, 4S)
- ☐ 2 Extension cords
- ☐ 6 Lamps with 60 W equivalent LED bulbs
- ☐ 4 Boxes with polarizing filter taped to top labeled with light level
- ☐ Box with no holes labeled “level 0”

Lead Box:

- ☐ 3 Extra student notebooks
- ☐ Lead instructions
- ☐ Respiration picture packet
- ☐ Lead lab coat
- ☐ Time card
- ☐ 2 Pencils
- ☐ 2 Red pens
- ☐ Wet erase markers
- ☐ Notepad
- ☐ Day 3.5 instructions

Notebook Pages:

**Scientific Practices**

**Procedure**

Directions: Read the following procedure that is based on the question and experimental set-up on page 8 and underline controls, changing variables, and box data collection. If any controls are missing or incorrect, add the correct values to the procedure. Remove any extra or irrelevant information from the procedure by crossing it out. If any steps are out of order, draw an arrow (=>) to indicate the correct order.

**PROCEDURE**

1. Get 4 small bottles with original solution.
2. Put no animals and aquatic plant in bottles and put the cap on.
4. Wait for 24 hours.
5. Observe and record the color of the solution.

PROCEDURE Note:

Make sure to include all values of your changing variable in the procedure (e.g., for a subgroup that decided to change solution type one step would be get 4 small bottles with solution type A, B, C, D, E solution, F yellow solution, G strong solution).

1. Get 4 small bottles with original solution.
2. Put no animals and aquatic plant in bottles and put the cap on.
4. Wait for 24 hours.
5. Observe and record the color of the solution.

In your procedure underline controls, circle changing variables, and box data collection.
**Preparation:**

**SciTrek Lead:**
1. Make sure volunteers are passing out notebooks.
2. If the classroom has a document camera, ask the teacher to use it for the Procedure Activity (page 9, student notebook), Procedure Activity experimental set-up (page 5, picture packet), procedure (page 6, student notebook), and results table (page 10, student notebook). If the classroom does not have a document camera, then tape the poster-size notebook pages to the front board.
3. Put the supplies (boxes, lamps, and bottles) for Day 3.5 in a continent spot. Verify the teacher knows when Day 3.5 will occur.
4. Get a small bottle to show students during the procedure discussion.

**SciTrek Volunteers:**
1. Pass out notebooks/nametags.

**Note:** Pass out notebooks to students. If needed, students will move to their subgroups after the Procedure Activity.

**Introduction:**
*(3 minutes – Full Class – SciTrek Lead)*

If students are not in their subgroups, tell them, “You will move to your subgroups after the Procedure Activity.”

Ask the class, “What is the class question we are investigating?” Students should reply, “What variables affect the color of the solution?” Tell them, “Today you are going to get to write a procedure for your
experiment.” Ask students, “What is a procedure?” Students should reply, “A set of steps to conduct an experiment.”

Procedure Activity:
(15 minutes – Full Class – SciTrek Lead)

Tell students, “We are now going to look at a complete procedure for the experimental set-up that we were working with during the last SciTrek visit.” Show students the experimental set-up and review the question, changing variable, and controls (page 8, student notebook or page 5, picture packet). Tell students, “The last time SciTrek was here we looked at individual steps to see if they could be correct for the given question and experimental set-up, today we are going to correct a possible complete procedure for the same experiment.” Have students turn to page 9 in their notebooks while you do the same in the class notebook. Read each step of the procedure and have students tell you what you should underline/circle/box (controls/changing variable/data collection) for each step (shown below). Ask students, “What should you include in a procedure?” Students may answer with any of the following listed in bold below. Cover each of the m in the order they are brought up, not the listed order, but make sure to cover all of them by the end of the conversation.

A complete procedure must have all values of the controls and the changing variable.
Ask students, “Are all control values listed in the procedure?” Go through the list of controls and put a check by them on the experimental set-up as students identify them in the procedure. Students should notice that one of the controls, ball mass, is not included. Ask students, “What step should the ball mass be included in?” They should reply, “Step 1.” Have students use a caret to write in 623 g before “rubber balls” in step 1 so that it reads: Get four 623 g rubber balls with circumferences of 88 cm.

A complete procedure must have what data will be collected (measurements/observations).
Ask students, “Is the data that will be collected listed in the procedure and, if so, in what step?” Students should reply, “Yes, the data that will be collected is listed in step 6.” Students should notice that all of the information needed in step 6 is present, and that this aspect of the procedure is complete.

A complete procedure must have the steps listed in the order they will be completed.
Ask students, “Are the steps listed in the correct order?” Go through the procedural steps once more and the students should notice that steps 3 and 4 are listed in the incorrect order. Draw a double-headed arrow to indicate that steps 3 and 4 should be switched with one another.

A complete procedure must never have extra or irrelevant information.
Ask students, “Is there any extra or irrelevant information about the experiment in this procedure?” Students should notice that passing the ball back and forth with one other person (step 5) does not help the scientist answer their original question, so this step is irrelevant. Have students cross out this step.

A complete procedure must never have opinions about the experiment.
Ask students, “Are there any opinions in the procedure?” Students should notice that step 7, “Have fun,” is an opinion. Students should say that not every scientist who performs this experiment will think that bouncing different temperature rubber balls is fun, therefore, this is an opinion. Because opinions cannot be tested, this step is incorrect. Have students cross out this step.
A complete procedure must never have incorrect values of the controls or the changing variable.
Ask students, “Are all control and changing variable values correct in the procedure?” Go through the list of controls and confirm that all but one of the controls is correct. Students should identify that the ground type listed in step 4 is incorrect. Have students cross out “gravel” and write “cement.”

**PROCEDURE**

1. Get four rubber balls with circumferences of 88 cm.
2. Heat balls to a temperature of 1) 30°C, 2) 40°C, 3) 50°C, 4) 60°C
3. Drop each ball.
4. Hold each ball at a height of 3 m over cement.
5. Pass the ball back and forth with one other person.
6. Measure how high each ball bounces.
7. Have fun.

**Procedure Discussion/Procedure:**

(35 minutes – Full Class/Subgroups – SciTrek Lead/SciTrek Volunteers)

Tell students, “In order to give you an example of how to write a procedure for your experiments, we will write a procedure together for the class experiment. It is helpful to be able to see both your procedure and your experimental set-up at the same time.” Have students open their notebooks as shown in the picture below so that they can see both page 5 and 6. Place the class notebook under the document camera open to page 9. Ask students, “What is the class research question?” Students should reply, “If we change the animal type, what will happen to the color of the solution? Ask students, “What needs to be included in a procedure?” Make sure that students come up with the following three items: 1) all values of the controls and changing variable, 2) what data will be collected, and 3) the steps listed in the order they will be completed.
Go over the experimental set-up (page 5, student notebook) from Day 2 for the class experiment. Tell students, “I will write down a step of the procedure for the class experiment, then you will write a step for your experiment. Remember, you should NOT copy the class procedure into your notebooks.”

Inform students, “Your requested bottles will already be labeled and contain solution when you get them.” Show them a small bottle of blue solution. Ask them, “Knowing this, what should the first step of the procedure be about?” Lead them to understand that it should be about getting the bottles. Then turn to the experimental set-up (page 5, student notebook) and ask them, “Which controls/changing variable should be included in the first step?” Put a small horizontal line next to each one they suggest (solution type and bottle size). Ask students, “Can someone put these variable values into a complete sentence for me?” Possible student response: get 4 small bottles with original solution. Write the step in the class notebook, then ask students, “What should we underline/circle/box in this step?” Then underline/circle/box the correct information. (Get 4 small bottles with original solution.) Tell students, “In your subgroup you will now write the first step of your procedure, focusing only on bottle size and solution type. You will then underline/circle/box the correct information. Remember, if your changing variable was bottle size, you will need to include all of the bottle sizes in your first step.” Read the example step on page 6 of the student notebook to give students an example of how to do this. Give students a few minutes to work in their subgroups to finish step one. While subgroups are working, their volunteers should help them. If needed, subgroups can dictate the step to volunteers, and they can write it on the small notepad found in their box and give it to students to copy into their notebooks. If a volunteer is working with multiple subgroups, they should help the subgroup with a changing variable in the current step first.

Once students have written their first step, ask them, “What should the second step in the procedure be about?” Lead them to understand that it should be about filling the bottles with the needed materials. Then, turn to the experimental set-up (page 5, student notebook). Turn the horizontal lines next to the variables used in step 1 into plus signs by drawing a vertical line through them. Tell students, “This indicates that these variables have already been used in the procedure.” Ask students, “Which controls/changing variable should be included in the second step?” Put a small horizontal line next to each one they suggest (animal type, plant type, and cap placement). Ask students, “Can someone put these variable values into a complete sentence for me?” Possible student response: put the animals in the bottles A) fish, B) frog, C) shrimp, and D) snail with no plants and put the cap on. Write the step in the class notebook, then ask students, “What should we underline/circle/box in this step. Then underline/circle/box the correct information. (Put no plants and A) fish, B) frog, C) shrimp, and D) snail in the bottles and put the cap on.) Tell students, “In your subgroup you will now write the second step of your procedure, focusing only on animal type, plant type, and cap placement. You will then underline/circle/box the correct information.”
Once students have written their second step, ask them, “What should the third step in the procedure be about?” Lead them to understand that it should be about putting the bottles under the correct light. Then turn to the experimental set-up (page 5, student notebook). Turn the horizontal lines next to the variables used in step 2 into plus signs. Ask students, “Which controls/changing variable should be included in the third step?” Put a small horizontal line next to each one they suggest (light amount). Ask students, “Can someone put this variable value into a complete sentence for me?” Possible student response: put the bottles under level 5 (full) light. Write the step in the class notebook, then ask students, “What should we underline/circle/box in this step?” Then underline/circle/box the correct information. (Put the bottles under level 5 (full) light.) Tell students, “In your subgroup you will now write the third step of your procedure, focusing only on light amount. You will then underline/circle/box the correct information.”

Once students have written their third step, ask them, “What should the fourth step in the procedure be about?” Lead them to understand that it should be about letting the bottles sit. Then turn to the experimental set-up (page 5, student notebook). Turn the horizontal lines next to the variables used in step 3 into plus signs. Ask students, “Which controls/changing variable should be included in the fourth step?” Put a small horizontal line next to each one they suggest (time). Ask students, “Can someone put this variable value into a complete sentence for me?” Possible student response: wait for 24 hours. Write the step in the class notebook, then ask students, “What should we underline/circle/box in this step?” Then underline/circle/box the correct information. (Wait for 24 hours.) Ask students, “Will all subgroups be waiting for 24 hours?” Students will reply, “Yes.” Tell them, “Since we are all doing the same thing, for this step, we can all copy this exactly as it is into our notebooks.” Give students a couple minutes to write this in their notebook and underline/circle/box the correct information.

Once students have written their fourth step, ask them, “What should the fifth step in the procedure be about?” Lead them to understand that it should be about data collection. Ask students, “Can someone tell me, in a complete sentence, what we will record at the end of the experiment?” Possible student response: observe and record the color of the solution. Write the step in the class notebook, then ask students, “What should we underline/circle/box in this step?” (Observe and record the color of the solution.) Then underline/circle/box the correct information. Ask students, “Will all subgroups observe the color of the solution?” Students will reply, “Yes.” Tell them, “Since we are all doing the same thing, for this step, we can all copy this exactly as it is into our notebooks.” Give students a couple minutes to write this in their notebook and underline/circle/box the correct information.

Flip back to page 5 in the student notebook. Turn the horizontal line next to the variable used in step 4 into a plus sign and ask students, “Do we have all the variable values in our procedure?” Students should reply, “Yes.” This indicates that the procedure is completed.

Below is what the class experimental set-up should look like with plus signs next to all control and changing variable values to indicate they have been included in the procedure. In addition, there is an example of a subgroup’s procedure.
Tell students, “Now that we have our procedure done, we need to fill out our results table.” Put the results table (page 10, student notebook) under the document camera. Go through the variables and the data and have students tell you, for the class experiment, if they are controls, changing variables, or data collection and underline, circle, or box them. Tell students “For controls, we will just write the value in the trial A box and then draw an arrow through the remaining trials’ boxes. For the changing variable, you will write the value in each box.” Record an example control value and changing variable values on the results
table with the students, see example below (left). Tell students, “Once you have filled out the results table, you will make predictions about what color the solution will be after 24 hours.” Have the class predict the color of the solution in the bottles after 24 hours for the class experiment by voting. Then record the answer that gets the most votes. After, allow a few students to share their reasoning for their prediction. While students are filling out their results table, fill in the rest of the results table for the class experiment.

**Results Table:**
(5 minutes – Subgroups – SciTrek Volunteers)

Have students underline the variables that are controls, circle the variable that is their changing variable, and box the information about data collection. When writing the values, make sure that for controls, they only write the value of the control in the trial A box and then draw an arrow through the remaining trials’ boxes. For the changing variable, they should write the value in each trial’s corresponding box.

When students have finished, have them make predictions about what the color of the solution will be after 24 hours by circling the predicted color. It is okay if the students in a subgroup have different predictions. An example filled out results table is shown below (right).

**Wrap-Up:**
(2 minutes – Full Class – SciTrek Lead)

Tell students, “24 hours before the next session, you will start your experiments, without your volunteers. When SciTrek comes back, you will be recording the color of the solution and any observations about the bottles.”
Clean-Up:

1. Collect nametags.
2. Collect notebooks and give to the teacher for setting up the experiments on Day 3.5.
3. Leave the lamps, Xerox boxes, and bottles in the classroom.
4. Place all other materials into your group box and bring materials back to UCSB.

Lead Note: Give the class notebook and picture packet to the teacher for setting up experiments on Day 3.5

Day 3.5: Experiment
*Day 3.5 must be completed ~24 hours before Day 4. A SciTrek staff member will bring in all the plants/animals for the experiments on this day and help fill the students’ bottles.

Schedule:

Experiment (SciTrek Staff Member/Classroom Teacher) – 15 minutes

Materials Already in Classroom:

☐ (28) Labeled bottles (with group color, number, and trial letter) including class experiment bottles divided in two buckets
☐ (7) Extra Bottles (1XL, 1L, 1M, 4S)
☐ (2) Extension cords
☐ (6) Lamps with 60 W equivalent LED bulbs
☐ (4) Boxes with polarizing filter taped to top labeled with light level
☐ Box with no holes labeled “level 0”
☐ Student notebooks
☐ Class notebook
☐ Respiration picture packet
☐ Day 3.5 instructions

Materials:

☐ Day 3.5 instructions
☐ (2) Sharpies
☐ Masking tape
☐ (3) White rags
☐ Tupperware with requested aquatic plant 1 (plus 4)
☐ Tupperware with requested aquatic plant 2 (plus 4)
☐ Tupperware with requested aquatic plant 3 (plus 4)
☐ Tupperware with requested aquatic plant 4 (plus 2)
☐ Bag with requested tree leaf 1
(plus 2)
☐ Bag with requested tree leaf 2
(plus 2)
☐ Bag with requested flower 1
(plus 2)
☐ Bag with requested flower 2
(plus 2)
☐ Tupperware with requested snails (plus 4)
☐ Tupperware with lead animals (2 snails, 2 fish, 2 frogs, 2 shrimp)
☐ (35) Caps with holes

Preparation:

1. Verify the variable section of the class results table is completely filled in.
2. Set up the light level boxes (levels 0-4) in ascending order with the light turned on sitting on top of the boxes with the front lids removed (see picture below). Set-up two additional lamps for level 5 lighting (this will not be in a box). Do not plug extension cords into other extension cords.
3. Set out the bottle, organized by subgroup, in an area that is easy for students to access.
4. Have the plant and animal Tupperware ready to pass plants and animals out to students.
5. Have notebooks in stacks by subgroups. Students will not need these until they fill their bottles.

**Experiment:**
*(15 minutes – Full Class – SciTrek Staff Member/Classroom Teacher)*

Tell students, “Today you are going to start your experiment.” Place the class procedure under the document camera (page 6, student notebook). “We will first set up the class experiment together and then you will be called by subgroup to start your experiments.”

Read step 1 of the class procedure, “Get 4 small bottles with original solution”. Show students the bottles for the class experiment.

Read step 2 of the class procedure, “Put no plants and A) fish, B) frog, C) shrimp, D) snail in the bottle and cup the cap on”. Put the animals in each bottle and then put the caps with holes on the bottles. Tell students, “When you start your experiment, you will all get to look at the animal bottles up close.”

Read step 3 of the class procedure “Place the bottle under level 5 (full) light”. Show students where the light level boxes are and put the class bottles under the appropriate light.

Read steps 4 and 5, “Wait 24 hours. Observe and record the color of the solution”. Tell students, “Your volunteers will be back tomorrow to help you record your data.”

The teacher can give the class something to work on while each subgroup is called one by one to fill and place their bottles under the appropriate light. Have the students read and follow the steps of their procedure.

Once a subgroup is done, call the next subgroup to start their experiment.

Collect notebooks from students.

Leave bottle caps with no holes and bucket in the classroom for Day 4.
# Day 4: Experiment/Results Summary/Poster Making

**Schedule:**

- **Introduction** (SciTrek Lead) – 7 minutes
- **Experiment** (SciTrek Volunteers) – 5 minutes
- **Results Summary** (SciTrek Volunteers) – 10 minutes
- **Poster Making** (SciTrek Volunteers) – 33 minutes
- **Wrap-Up** (SciTrek Lead) – 5 minutes

**Materials:**

<table>
<thead>
<tr>
<th>(3) Volunteer Boxes:</th>
</tr>
</thead>
<tbody>
<tr>
<td>□ Student nametags</td>
</tr>
<tr>
<td>□ Volunteer instructions</td>
</tr>
<tr>
<td>□ Volunteer lab coat</td>
</tr>
<tr>
<td>□ Poster diagram</td>
</tr>
<tr>
<td>□ (2) Sticker sets on how to present results (changing conditions/changing contents)</td>
</tr>
</tbody>
</table>

| □ (2) Pencils       |
| □ Notepad           |
| □ (9) Paperclips    |
| □ Highlighter        |
| □ Scissors          |
| □ (2) Glues         |

| □ (2) Poster parts packs |
| (scientists’ names, question, experimental set-up, procedure, results table, results summary, (6) “I acted like a scientist when,” (6) picture spaces) |

**Other Supplies:**

- □ Poster paper tube

**Lead Box:**

- □ (3) Extra student notebooks
- □ Lead instructions
- □ Respiration picture packet
- □ Poster diagram
- □ Lead lab coat
- □ Time card

- □ (2) Sticker sets on how to present results (changing conditions/changing contents)
- □ (2) Pencils
- □ (2) Wet erase markers
- □ Notepad
- □ (9) Paperclips

- □ (2) Highlighters
- □ (2) Scissors
- □ (2) Glues
- □ Scotch tape
- □ (2 each color) Poster part packs
- □ (24) Caps with no holes
Notebook Pages:

**Preparation:**

**SciTrek Lead:**
1. Get students’ notebooks from the teacher and give them to the volunteers to separate into their subgroups, attach nametags, and set out.
2. Make sure volunteers get bottles for their subgroups and replace the caps with holes with caps without holes.
3. Ask the classroom teacher for a place to leave student posters.
4. If the classroom has a document camera, ask the teacher to use it for the results table (page 10, student notebook) and results summary (page 11, student notebook). If the classroom does not have a document camera, then tape the poster-size notebook pages to the front board.

**SciTrek Volunteers:**
1. Get notebooks from the lead, separate them into subgroups, and attach nametags.
2. Set out notebooks/nametags.
3. Get bottles for your subgroups. Replace caps with holes with caps that do not have holes.

**Note:** Set notebooks where students will sit during the module even if another student is currently at that desk. If needed, students will move to these spots after the introduction.

**Introduction:**
(7 minutes – Full Class – SciTrek Lead)

If students are not in their subgroups tell them, “A notebook will be put on your desk, which is not your notebook and you should not move it. You will move to your subgroups after the introduction.”
Ask the class, “What is the class question we have been investigating?” Students should reply, “What variables affect the color of the solution?” Tell students, “Today you are going to record your data and analyze the results from your experiments which will allow you to start answering the class question. Before you record your data, as a class we will record the data from the class experiment.” Show students the four bottles from the class experiment and record the color of the solutions as well as any additional observations. An example of the class results can be seen below on the left.

Tell students, “We will now analyze the class data together.” Put the filled-out results table from the class experiment under the document camera (page 10, student notebook). Have students compare the actual and predicted colors to see if they match. Tell students, “We will now work together to try to determine any patterns that cause the solutions to change colors.”

Ask students, “What patterns do you see in the results?” Possible student response: all the solutions that had animals turned yellow. Ask students, “Can we test if all animals will turn the solution yellow?” Students should reply, “Yes.” Tell them, “If a statement is testable, then it is a claim and claims are the first part of results summaries.” Write “when an animal is present the solution turns yellow regardless of the animal type” in the class notebook.

**Note:** If you would like to push student thinking further you can have them make a claim about why they think the solution is turning color. Such as these example claims:

- My experiment shows that when animals go to the bathroom the solution turns yellow
- My experiment shows that when animals breathe the solution turns yellow
- My experiment shows that when animals produce CO₂ the solution turns yellow

Tell students, “You now need to use data to support your claim. There are two forms of data: observations and measurements.” Ask students, “What type of data will we use to support our claim?” Students should reply, “Observations.” Tell students, “In order for everyone to know that we carried out the experiment, we will start the data statement with ‘we observed.’” Write the following data statement
after the claim in the class notebook: “because we observed that the fish, shrimp, frog, and snail turned the solution yellow.”

Tell students, “Result summaries are strongest when they allow us to make predictions.” Ask students, “Based on our results summary can you predict something else that would turn the solution yellow?” Possible student response: worm.

Tell students, “After you summarize your experimental findings, you will fill in the sentence frame ‘I acted like a scientist when,’ stating how you acted like a scientist during your SciTrek experience. Try to come up with a unique answer that is something besides ‘I did an experiment.’”

Tell students, “When scientists complete their experiment, they make a poster to present their work to other scientists. Each subgroup will create a poster to present to the class during the next session. This presentation will be your chance to tell the class what your subgroup has discovered about the class question. You should write as neatly as possible on the poster parts so that the other class members can read your poster. You will now start working with your subgroup to analyze your experimental results and then make a poster.”

Experiment
(5 minutes – Subgroups – SciTrek Volunteers)

Have students look at their experiment bottles and record their results. All members of a subgroup should agree on the colors they record. If students are having difficulty, place bottles on a white sheet of paper to see the color better. An example of a student’s results can be seen below.
Results Summary:
(10 minutes – Subgroups – SciTrek Volunteers)

Have students summarize their findings. Challenge students to think about how their changing variable did or did not affect the solution color.

When writing their results summary (page 11, student notebook), make sure students begin the statement with a claim (a statement that can be tested) about the trend or pattern in their data. If possible, try to have students generate a claim that allows them to make predictions about something that they have not tested. An appropriate claim could be: when an aquatic plant is present, as the light level decreases the solution turns yellow. This is an appropriate claim because it allows the students to make a prediction about what would happen if new values of their changing variable were introduced.

After generating a claim about their experiment, students will write the word “because” and follow it with supporting data. Their supporting data should include at least two pieces of data. Make sure students are using their changing variable values (not trial letters) and specific colors to support their claim. Since the data is in the form of observations, all data statements should include the words “we observed.” The supporting data for the previously mentioned claim would be: because we observed that the solution in light level 0 (no light) turned yellow, but the solution in light level 5 (full light) stayed blue.

Results summaries are still valid, and important, if they show that the changing variable tested did not affect the color of the solution. Even if their results summary is contrary to what you think, have students make a claim based solely on their data. An example filled out results summary is shown below.

![Results Summary](image)

Once students are done with their results summary, take away their experimental bottles and put them in the bucket.
Before starting their poster, have students fill in the sentence frame (page 11, student notebook), “I acted like a scientist when.” Each student’s response should be unique and specific. They should NOT write, “when I did an experiment,” because this is general and applies to all of the students in the class. If students are having trouble with this sentence frame, ask them, “What did you do during SciTrek?”

**Poster Making:**
*(33 minutes – Subgroups – SciTrek Volunteers)*

Each subgroup (four/five/six students) will make one poster about their experiment.

Pass out the writing portions (general poster parts and “I acted like a scientist when”) and have students write their names on them and complete them. In addition, have each student write their name on the scientists’ names poster part. Use the following guidelines when assigning poster parts:

<table>
<thead>
<tr>
<th>Number of Students in Subgroup</th>
<th>Poster Division</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Each student gets an “I acted like a scientist when” and picture space.</td>
</tr>
<tr>
<td></td>
<td>1. Question and Experimental Set-Up</td>
</tr>
<tr>
<td></td>
<td>2. Procedure</td>
</tr>
<tr>
<td>4</td>
<td>3. Results Table*</td>
</tr>
<tr>
<td></td>
<td>4. Results Summary</td>
</tr>
<tr>
<td></td>
<td>5. Results Summary</td>
</tr>
<tr>
<td>5</td>
<td>1. Question</td>
</tr>
<tr>
<td></td>
<td>2. Experimental Set-Up</td>
</tr>
<tr>
<td></td>
<td>3. Procedure</td>
</tr>
<tr>
<td></td>
<td>4. Results Table*</td>
</tr>
<tr>
<td></td>
<td>5. Results Summary</td>
</tr>
<tr>
<td>6</td>
<td>1. Question</td>
</tr>
<tr>
<td></td>
<td>2. Experimental Set-Up</td>
</tr>
<tr>
<td></td>
<td>3. 1st Half of Procedure</td>
</tr>
<tr>
<td></td>
<td>4. 2nd Half of Procedure</td>
</tr>
<tr>
<td></td>
<td>5. Results Table*</td>
</tr>
<tr>
<td></td>
<td>6. Results Summary</td>
</tr>
</tbody>
</table>

*Procedure can be cut in half.

*Give the results table to the student that is most confident in presenting.*

Once students have finished their written section(s), have them draw a picture of their experiment or how they acted like a scientist.

In the students’ notebooks, highlight and number the section(s) that they will present. The parts should be numbered as follows: 1) scientists’ names, 2) question, 3) experimental set-up, 4) procedure, 5) results table, and 6) results summary (see example below). Students will NOT present “I acted like a scientist when” part from their poster. If a student is presenting multiple sections, use the paperclips in your group box to clip together the sections that they are reading so that when presenting, it will be easy for them to flip back and forth between pages.
Place one of the following sentence frame stickers on the notebook page of the student who is presenting the results table (page 11, student notebook). If your group is testing bottle size, write “the _____ bottle” in the first blank in the conditions sentence frame.

### Changing Bottle Content (plant type):

The solution that contained __________ was observed to be ____________.

### Changing Conditions (light amount or bottle size):

The solution that was in __________ was observed to be ____________.

Then, practice reading the four sentences with that student. For the results table above, the first sentence would read: The solution that was in level 0 light was observed to be yellow. To make this easier for students you can write level ___ light on the first blank of the sentence frame if the group’s changing variable was light level. An example sentence frame for a group that changed bottle size would be: The solution that was in the small bottle was observed to be yellow (words in italics were written-in to sticker).
As soon as students have completed some of their pieces, start gluing them onto the large poster paper, in landscape orientation, exactly as they are arranged in the example below. Do not allow students to glue the poster parts on the poster. Do not wait until students have completed all the pieces to start gluing them onto the poster.

Once the poster is complete, have students start practicing for the presentation. Make sure students read from their notebooks, instead of from the poster.

Ask each of your subgroups a few questions about their poster. Have them use their findings to predict what would happen to the color of the solution for other changing variable values that they did not test. For instance, if the subgroup’s results summary was, “My experiment shows that when aquatic plants are in the bottles the solution stays blue, because we observed that all of the solutions stayed blue even though they had different types of aquatic plants (aquatic plant 2 and aquatic plant 3) in them,” ask the subgroup to predict what the color of a bottle would be if it contained aquatic moss. They should be able to predict that it would be blue.

If there is additional time, tell each subgroup, “Other students will ask you questions during your poster presentations. You should think about what questions you will be asked, and then think of the answers to those questions, so that you will be prepared during your presentation.”

Wrap-Up:
(5 minutes – Full Class – SciTrek Lead)

Ask students the following questions:
How did you act like a scientist during this project?
What did you do that scientists do?

After discussing how they acted like scientists and talking about how everyone does things that scientists do in their everyday lives, tell students, “Next session, you will present your findings to the class. I am looking forward to hearing about all of your experiments.”
Clean-Up:

1. Collect notebooks with attached nametags.
2. Leave posters in the classroom.
3. Place all other materials into your group box and bring materials back to UCSB.

Day 5: Poster Presentations

Schedule:

- Introduction (SciTrek Lead) – 2 minutes
- Practice Posters (SciTrek Volunteers) – 10 minutes
- Poster Presentations (SciTrek Volunteers/SciTrek Lead) – 46 minutes
- Wrap-Up (SciTrek Lead) – 2 minutes

Materials:

(3) Volunteer Boxes:
- ☐ Student nametags
- ☐ Student notebooks
- ☐ Volunteer instructions
- ☐ Volunteer lab coat
- ☐ (2) Pencils
- ☐ (6) Paperclips
- ☐ Highlighter
- ☐ (12) Sharpened SciTrek pencils (all same color)

Lead Box:
- ☐ (3) Extra student notebooks
- ☐ Lead instructions
- ☐ Respiration picture packet
- ☐ Lead lab coat
- ☐ Time card
- ☐ (2) Sticker sets on how to present results (changing conditions/changing contents)
- ☐ (2) Wet erase markers
- ☐ (9) Paperclips
- ☐ (2) Highlighters
- ☐ Scotch tape

*Student posters should already be in the classroom.
**Picture Packet Pages:**

### Preparation:

**SciTrek Lead:**
1. Make sure volunteers are passing out notebooks.
2. If the classroom has a document camera, ask the teacher to use it for the Notes on Presentations (pages 6 and 7, picture packet). If the classroom does not have a document camera, then write the class question on the board, “What variables affect the color of the solution?” Leave enough room to record student findings under the question.
3. Organize posters so experiments featuring the same changing variable are presented back to back and posters are presented from simplest to understand to most difficult to understand (suggested order: bottle size, plant type, light amount (animal), light amount (plant), light amount (animals and plants)).

**SciTrek Volunteers:**
1. Pass out the notebooks/nametags.
2. Have pencils ready to distribute to your groups after the poster presentations.

**Note:** Today students will sit in their regular classroom seats during poster presentations.

### Introduction:

**2 minutes – Full Class – SciTrek Lead**

Tell students, “Today you will present your posters to the class. This is a common practice in science. Scientists go to conferences where they present posters about the experiments they conducted. At these presentations, other scientists give them feedback on their experiments, which allows them to return to the lab with new ideas for future experiments.”
Tell students, “You will have 10 minutes to practice presenting your poster with your subgroup. When you present, you should read from your notebooks, not the poster. After practicing, you will return to your normal classroom seats.”

**Practice Posters:**
**10 minutes – Subgroups – SciTrek Volunteers**

If the posters are not already in order, the lead should organize posters so experiments featuring the same changing variable are presented back to back and posters are presented from simplest to understand to most difficult to understand (suggested order: bottle size, plant type, light amount (animal), light amount (plant), light amount (animals and plants)).

Have subgroups practice their poster presentation, making sure they are reading the poster parts in the correct order (scientists’ names, question, experimental set-up, procedure, results table, and results summary). Make sure each student’s part is highlighted in their notebook. If students are reading from multiple pages, use a paperclip to clip these pages together to make it easier for them to flip back and forth. Remind students to read from their notebook rather than from their poster.

If there is additional time, tell the subgroup, “Other students will ask you questions during your poster presentations. You should think about what questions you will be asked and then think of the answers to those questions so that you will be prepared during your presentation.”

Do not let poster practice go over 10 minutes.

**Poster Presentations:**
**46 minutes – Full Class – SciTrek Volunteers/SciTrek Lead**

Have students return to their original class seats. Ask the class, “What is the question we have been investigating?” Students should reply, “What variables affect the color of the solution?” Tell students, “During the presentations, I will take notes, but you will have to help me by telling me the changing variable of the subgroup after they say their question. I will also record the subgroups’ changing variable values and the corresponding color of the solution.” Turn to page 7 in the picture packet.

Tell students, “You will get to ask questions after the presentation. These questions are important because you will have to summarize what you learned from the subgroup so I can record it on the subgroup notes. Therefore, your questions should focus on helping you be able to summarize the subgroup’s findings. If you ask a scientific question during the presentation, you will get a SciTrek pencil at the end of the presentations.”

Volunteers should make sure that students are quiet and respectful when other subgroups are presenting. When one of your subgroups is presenting, go to the front of the room with them; prompt students if they do not know who talks next and remind them to read from their notebooks.

During the student question time, the lead and/or volunteers should ask at least one question. Examples of possible questions are: “How do you know...?” or “Is there anything else you can do to get more information about your question?” Each subgroup should answer approximately five questions (one question per student). When students are done asking questions, have them summarize what the subgroup found.

An example filled out Notes on Presentations are shown below.
After all poster presentations have been given, ask the class, “What did we learn about the color of the solution?” Have them summarize the class findings. The highlights from many experiments are shown below. Do not expect students to know highlights from experiments that were not run.

- The larger the bottle size the bluer the solution.
- When the plant type is a non-aquatic plant (leaves/flowers), the solution will turn yellow/green regardless of the light amount. (Note: In general, flowers do not undergo photosynthesis, but they do undergo respiration. Tree leaves have not adapted (like aquatic plants have) to be able to take in CO$_2$ from the water. This is because their stomata are blocked by the water, which results in the leaf only undergoing respiration.)
- The light amount will not affect the color of the solution (all solutions will be yellow) if only snails are present.
- The light amount affects the color of the solution when an aquatic plant is present.
  - Placing any type of aquatic plant in the light will keep the solution blue.
  - Placing any type of aquatic plant in the dark will turn the solution yellow.
- The light amount affects the color of the solution when an aquatic snail and plant are both present.
  - Placing any type of aquatic plant and a snail in the light will cause the solution to be less yellow (more green) than with the animal alone.
  - Placing any type of aquatic plant and a snail in the dark will make the solution yellow.

When summarizing experiments, use student-collected data and not what they should have found from the list above. Ask students, “If I want to get a solution to turn as yellow as possible, what values of variables should I use?”

- Animal Type: Any animal
- Bottle Size: Small
- Plant Type: Any aquatic plant.
- Light Amount: Dark
If no one in the class did experiments on one of the variables above, then they will not know how that variable affects the color of the solution, and do not expect them to tell you which value to use. Tell students, “You have taught me a lot about what causes the solution to change colors.”

Wrap-Up:
(2 minutes – Full Class – SciTrek Lead)

Tell students, “The mentors who have been working with you are undergraduate and graduate students that volunteer their time so you can do experiments. This is the last day you will see your volunteers so we should say thank you and goodbye to them. I will come back and work with you one more day.”

Have students remove the paper part of their nametag (which they can keep) from the plastic holder, and return the plastic holder to their volunteer.

Have volunteers pass out pencils to the students that asked questions. If a student did not ask a question during the poster presentations, have them ask/answer a question about the experiments before the volunteer gives them a pencil.

Clean-Up:

1. Collect plastic nametag holders and allow students to keep the paper part of their nametags.
2. Collect notebooks.
3. Leave posters in the classroom.
4. Place all other materials into your group box and bring materials back to UCSB.
5. If you will not be attending the Tie to Standards day, remove all materials from your lab coat pockets, remove your nametag, unroll your lab coat sleeves, and put your lab coat into the dirty clothes bag at UCSB.

Day 6: Procedure Assessment/Tie to Standards

Schedule:

Procedure Assessment (SciTrek Lead) – 10 minutes
Tie to Standards (SciTrek Lead) – 50 minutes

Materials:

Lead Box:
☐ (3) Extra student notebooks ☐ Lead lab coat ☐ (2) Wet erase markers
☐ Student notebooks ☐ Time card ☐ Straw
☐ Lead instructions ☐ (35) Procedure Assessments ☐ Tongs
☐ Respiration picture packet ☐ (2) Pencils

Other Materials: (these bottles should be in a cardboard box so students cannot see them)
☐ B0, B00, and B000: 3 bottles of blue solution (half full)
☐ B1: snail/light for 24 hrs
☐ B2: frog/light for 24 hrs
☐ B3: fish/light for 24 hrs
☐ B4: plant 1/light for 24 hrs
☐ B5: plant 2/light for 24 hrs
☐ B6: snail/dark for 24 hrs
☐ B7: frog/dark for 24 hrs
☐ B8: fish/dark for 24 hrs
☐ B9: plant 1/dark for 24 hrs
☐ B10: plant 2/dark for 24 hrs
☐ Small piece of dry ice
☐ Balloon with car exhaust
RESULTS
Summary

My experiment shows that when an aquatic plant is present, as the light level decreases, the solution turns yellow because we observed the solution in light level 0 (no light) turned yellow, but the solution in light level 5 (full light) stayed blue.

I acted like a scientist when I collected data by observing the colors of the solutions.

TIE TO STANDARDS

1. Fill out the following table. First predict the color of the solution based on the following contents/conditions. After each bottle is shown, record the actual solution color. (y-yellow, g-green, b-blue)

<table>
<thead>
<tr>
<th>Experiment Number</th>
<th>Bottle Contents</th>
<th>Bottle Conditions</th>
<th>Predicted Color</th>
<th>Actual Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Snail</td>
<td>24 Hours Dark</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>2</td>
<td>Frog</td>
<td>24 Hours Dark</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>3</td>
<td>Fish</td>
<td>24 Hours Dark</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>4</td>
<td>Aquatic Plant 1</td>
<td>24 Hours Light</td>
<td>b</td>
<td>b</td>
</tr>
<tr>
<td>5</td>
<td>Aquatic Plant 2</td>
<td>24 Hours Light</td>
<td>b</td>
<td>b</td>
</tr>
</tbody>
</table>

2. From the chart above, what do the solutions that are yellow/green have in common?

They all have animals in them.

THE BROADER PICTURE

3. Use the graph below to answer the following questions about carbon dioxide.

- More humans
- Cars/factories
- Deforestation

4. Would there be carbon dioxide on the planet if humans did not exist?

- Yes
- No

5. Have humans changed the amount of carbon dioxide that is produced each year?

- Yes
- No

6. What are 2 things that humans do to decrease the amount of carbon dioxide they produce?

- Use cars less. (carpool, bike, walk)
- Plant more trees

7. What are 3 things that could contribute to the increasing amounts of carbon dioxide in the atmosphere?

- More humans
- Cars/factories
- Deforestation

8. What are 2 things that could contribute to the increasing amounts of carbon dioxide in the atmosphere?

- More humans
- Cars/factories

Carbon dioxide levels in the atmosphere are increasing because in 1900, there were 300 ppm of CO₂ and in 2000, there were 340 ppm of CO₂.
Preparation:

SciTrek Lead:

1. If the teacher is not leading the Tie to Standards Activity, do the following:
   a. Give the teacher an extra student notebook and have them fill it out with their students to follow along.
   b. Collect the teacher’s lab coat and put it in the lead box.
2. Pass out the Procedure Assessments and notebooks to students or get the classroom teacher to pass them out.
3. If the classroom has a document camera, ask the teacher to use it for the Tie to Standards Activity (pages 11-14, student notebook). If the classroom does not have a document camera, then tape the poster-size notebook pages to the front board.
4. Make sure the only bottles with blue solution are B0, B00, B000, B4, and B5. These are the bottles with nothing in them and the bottles with plants in the light.
5. Have the cardboard box with bottles ready with easy access to grab bottles after students make predictions.
6. Put your lab coat in the lead box at the end of the day.

Procedure Assessment:
(10 minutes – Full Class – SciTrek Lead)

“Before we start our activity today, we will determine how your ideas on procedures are developing.” Have students write their name, teacher’s name, and date on the top of the assessment. Students, “When doing this assessment, you should work individually so there should be no talking.” As you are giving the assessment, walk around the room and verify that students have written their name on their assessment.

Read the question, changing variable (Ex: the changing variable was liquid type), and controls (Ex: the controls were liquid amount, container type, object type…). You do not need to read the values of the changing variable or the controls. Then, read the directions to the students. Read each of the statements and have students underline controls/circle changing variables/box data collection before circling if the statement could be an appropriate procedure step. When students are finished, collect the assessments and verify that the students’ names are on the top of the papers.

Tie to Standards:
(50 minutes – Full Class – SciTrek Lead)

Predictions of Experimental Bottles in the Light: Bottles B1, B2, B3, B4, and B5 (12 minutes)

Have the students turn to page 11 in their notebooks. Tell students, “Today we are going to talk about your previous experiments and hopefully answer any questions that you still have about what is changing the color of the solution. Yesterday I started an experiment and brought the bottles in for you to observe. These bottles all have different contents in them, but they were under the same conditions: under the light for 24 hours. Before I show you the bottles, I want you to predict the color of the solutions based on what you learned from the poster presentations. If you think the solution will be yellow you can record ‘Y,’ if you think the solution will be blue you can record ‘B,’ and if you think the solution will be green you can record ‘G.’” Have the students make all of the predictions at one time. Then, for each bottle have one student share what they think the color of the solution will be and why. Have the class vote, using thumbs up/thumbs down if they agree/disagree with the student. If many students disagree, ask one of the students that disagrees what they think and why. After, show the students the experimental bottle and have them record the actual color of the solution on their chart as you record the color in the class notebook. Then, leave each bottle on the table and continue onto the next bottle until you have gone through bottles B1-B5.
Ask students, “What do the solutions that turned yellow/green have in common?” Students should reply, “They contained animals.” If they bring up the fact that they were all in the light for 24 hours, ask students, “Was there any solution that was blue after being in the light 24 hours?” Students should reply, “The solutions with aquatic plants.” Tell them, “Since the aquatic plant solutions stayed blue it could not have been the light alone that was changing the color of the solution; therefore, the color change must have been caused by the animals themselves.” Record this for question 2 in the class notebook under the document camera for students to copy.

Have the students turn to page 12 in their notebooks.

Ask students, “Did all of the solutions that were under the light for 24 hours change color?” Students should reply, “No.” Have them check this box in their notebook for question 3. Ask students, “Why did some of the solutions remain blue?” Possible student response: they did not contain animals. Have students record their answer into their notebook. Ask one student to share their response and record this answer into the class notebook for question 4 for the students to copy.

**Determination of What is Causing Color Change: Bottles B0 and B00 (12 minutes)**

Ask students, “What do you think the animals are doing to change the color of the solution?” Lead a discussion until students say that the animals are breathing in O₂ and producing CO₂ and the CO₂ is changing the color of the solution to yellow.

Many times students suggest that the animals are going to the bathroom and this is what is changing the color of the solution to yellow. If this comes up, ask them, “Is there a way to test this?” Possible student response: if urine was placed in the solution without the animal, and the solution changes to yellow, then it would be urine that was changing the color of the solution. Tell them, “I have done this experiment and there was no observed color change. Therefore, this is not the reason that the solution is changing color.”

Ask students, “Is there any way we could confirm that CO₂ changes the color of the solution?” Possible student response: if CO₂ was placed in the solution without the animal and the solution turned yellow, then it would be CO₂ that was changing the color. Ask students, “Is there someplace that I can purchase CO₂?” Lead student to understand dry ice is solid CO₂ and can be purchased at the grocery store. Show the students the piece of dry ice. Tell students, “As the dry ice heats up, it turns back into CO₂ gas”. Ask students, “What should happen if I put a piece of the dry ice into the solution?” Possible student
response: if CO₂ is changing the color of the solution, the solution’s color will change to yellow. Put the piece of dry ice into bottle B0 to verify for students that CO₂ is changing the color of the solution.

Ask students, “Do you think I could change the color of the solution if I blew into the solution with a straw?” Have a few students share their ideas with the class and their reasoning behind the ideas. Do the experiment for the students. Remove the lid from the bottle B00, put the straw into the solution, and blow into the straw for approximately 20 seconds. After 20 seconds the solution will be a pale yellow/green color. Ask students, “How come I was able to change the color of the solution in very little time, but the other animals took 24 hours?” Possible student response: your lungs are much bigger than the other animals; therefore, you are able to produce more CO₂, and this changes the color of the solution faster.

Ask the class, “If I have a solution that has turned yellow, how can I get it to turn back to blue?” Lead the students in coming up with the idea that if a plant was put into the bottle and it was left in the light it should turn back to blue. **Note:** if the class would like to see this happen you can leave an aquatic plant in a yellow solution for them to observe.

**Note:** Why ONLY CO₂ can be detected in the bottles (not to be discussed with students).
When CO₂ dissolves in liquid water (H₂O) it produces carbonic acid (H₂CO₃) by the following reaction:

\[
\text{CO}_2(g) + \text{H}_2\text{O}(l) \rightleftharpoons \text{H}_2\text{CO}_3(aq)
\]
Carbonic acid (H₂CO₃) is an acid and thus makes the solution in the bottle more acidic. Bromothymol blue (the solution in the bottles) is a common pH indicator (which tells the amount of H⁺ [or acid] in the solution), which changes colors when the pH of the solution changes. Thus, the yellow color in the bottles indicates the presence of an acid (H₂CO₃) in the solution. With the bromothymol blue indicator, we can NOT tell anything about the presence of oxygen (O₂), since O₂ does not form an acid or a base when dissolved in the solution. Therefore, it is important that when referring to the color change we only talk about carbon dioxide amounts and not oxygen amounts.

**Prediction of Experimental Bottles in the Dark: Bottles B6, B7, B8, B9, and B10 (12 minutes)**

Tell students, “We are now going to make predictions about the experimental bottles that were left in the dark for 24 hours.” Similar to before, students will record their predictions first for all of the bottles. You can then have one student share what they think the color of the solution will be and why and use thumbs up/thumbs down to see if the class agrees. Then show students the bottles and have them record their observations on their chart as you record them in the class notebook for question 5.

<table>
<thead>
<tr>
<th>Experiment Number</th>
<th>Bottle Contents</th>
<th>Bottle Conditions</th>
<th>Predicted Color</th>
<th>Actual Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>Snail</td>
<td>24 Hours Dark</td>
<td>¥</td>
<td>¥</td>
</tr>
<tr>
<td>7</td>
<td>Frog</td>
<td>24 Hours Dark</td>
<td>¥</td>
<td>¥</td>
</tr>
<tr>
<td>8</td>
<td>Fish</td>
<td>24 Hours Dark</td>
<td>¥</td>
<td>¥</td>
</tr>
<tr>
<td>9</td>
<td>Aquatic Plant 1</td>
<td>24 Hours Dark</td>
<td>¥</td>
<td>¥</td>
</tr>
<tr>
<td>10</td>
<td>Aquatic Plant 2</td>
<td>24 Hours Dark</td>
<td>¥</td>
<td>¥</td>
</tr>
</tbody>
</table>

After completing the table, ask students, “What does the color of the solution tell us about animals in the dark?” Possible student response: since the solution changed colors, the animals are still producing CO₂, or breathing, in the dark. Write this response into the class notebook and have students copy the response into their own notebooks for question 6.
Ask students, “What does the color of the solution tell us about plants in the dark?” Possible student response: the plants in the dark turned the solution yellow therefore, the plants must be producing CO₂. Record this response into the class notebook for question 7 and have the students copy this into their notebooks.

Ask students, “What is the process called where plants turn CO₂ into O₂?” Students should reply, “Photosynthesis.” Ask students, “What is needed for photosynthesis?” Students should reply, “Light and CO₂.” Tell students, “Just like animals, plants take in O₂ and produce CO₂. However, when there is light, plants are able to photosynthesize and the amount of CO₂ that they produce is less than the amount of CO₂ that they consume.”

**The Broader Picture: Bottle B000 (14 minutes)**

Have the students turn to page 13 in their notebooks.

Have students look at the graph and answer questions a-d. Go over each of the questions as a class, calling on students to provide the answers. Record the answers in the class notebook for questions 8a-d for students to copy.

![Graph of Carbon Dioxide Levels in the Atmosphere](image)

**THE BROADER PICTURE**

8. Use the graph below to answer the following questions about carbon dioxide.

- a. What information is plotted on the x-axis? **year**
- b. What information is plotted on the y-axis? **CO₂ (ppm)**
- c. Does the level of carbon dioxide change over time? **yes**
- d. Circle the area(s) on the graph that do not fit the general trend, or that show the greatest change.

Ask students, “Can someone summarize what the graph tells us about the CO₂ levels in the atmosphere?” After students have told you their ideas, write the answer in 8e.
Ask students, “What is different now than in the 1800’s and before?” Possible student response: there were no cars in the 1800s. Ask students, “Do you think cars produce CO₂?” Tell them, “I have some exhaust from a car that I will bubble through the solution to see if cars produce CO₂.” Ask students, “If car exhaust has CO₂, what color will the solution turn?” Students should reply, “Yellow.” Ask students, “If car exhaust does not contain CO₂, what color will the solution be?” Students should reply, “Blue.” Get bottle B000 and bubble the exhaust through the solution. Do this by removing the binder clip from the balloon and carefully placing the opening over the straw. Insert the straw into the blue solution to allow the exhaust to go through the solution. The blue solution will turn yellow. If you do not use all of the exhaust, replace the binder clip on the balloon to reseal the balloon. Because the solution turned yellow from the car exhaust, we can conclude that cars are also producing CO₂.

Ask students, “What was the difference between the time it took my breath to turn the solution yellow compared to the time it took the car exhaust to turn the solution yellow?” Possible student response: the exhaust turned the solution yellow more quickly. Ask students, “What does this mean?” Possible student response: the car exhaust is producing much more CO₂ than what is produced during respiration.

Next, have the students turn to page 14 in their notebooks.

Ask students, “What are 3 things that contribute to the increasing amounts of carbon dioxide in the atmosphere?” Write some of the student ideas onto the class notebook for question 9 and have them copy these or their own ideas into their notebook.

9. What are 3 things that could contribute to the increasing amounts of carbon dioxide in the atmosphere?

   More humans
   Cars/factories
   Deforestation

Next, ask students, “Would there be CO₂ on Earth if humans did not exist?” Possible student response: other animals besides humans produce CO₂ and plants produce CO₂ when they are not photosynthesizing, so there would be CO₂ without humans. Have student check “yes” in their notebook for question 10.

10. Would there be carbon dioxide on the planet if humans did not exist?
   ☒ yes    ☐ no

Ask students, “Have humans changed the amount of carbon dioxide that is produced each year?” After hearing students’ ideas have them check “yes” in their notebook for question 11.

11. Have humans changed the amount of carbon dioxide that is produced each year?
   ☒ yes    ☐ no
Next, ask students, “What are 2 things that humans can do/already do to decrease the amounts of carbon dioxide they produce?” Record two of these responses in the class notebook for question 12 for students to copy.

12. What are 2 things that humans do to decrease the amounts of carbon dioxide they produce?

- Use cars less (carpool, bike, walk)
- Plant more trees

Tell students, “You can keep your notebooks. I have enjoyed learning science with you. I hope you will continue to see yourselves as scientists and explore the world around you. You will get another opportunity for SciTrek to come to your class, and run another long-term investigation with you, later in the year, so it is important that you remember what you have learned for your next module.”

Clean-Up:

1. Leave notebooks with students.
2. Place all other materials in the lead box and bring them back to UCSB.
3. Remove all materials from your lab coat pockets, remove your nametag, unroll your lab coat sleeves, and put your lab coat into the dirty clothes bag at UCSB.

Extra Practice Solutions:

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EXTRA PRACTICE
Procedures

QUESTION
If we change the [ ] that will happen to the [ ]

EXPERIMENTAL SET-UP
Changing Variables:

<table>
<thead>
<tr>
<th>Jam Type</th>
<th>Trial A</th>
<th>Trial B</th>
<th>Trial C</th>
<th>Trial D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strawbery</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Raspberry</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blackberry</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boysenberry</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Controls (variables you should hold constant):

<table>
<thead>
<tr>
<th>Jam Amount</th>
<th>Jam Brand / Additions</th>
</tr>
</thead>
<tbody>
<tr>
<td>200g</td>
<td>Jam Brand / Additions</td>
</tr>
</tbody>
</table>

Time: 15 hours

Distance from start: 1.5 cm

Container Type: Index Card

Art Type / Argentine Arts

Directions:
Step 1: Read each statement and underline controls, circle changing variables, and box information about data collection.
Step 2: Circle if the statement could be a correct step for a procedure about the question and experimental set-up above. If not, circle no.

Could this be a correct step?

1. Put type of additions (boysenberry, Blackberry, Raspberry) on index card A.
2. Put the sensory additions (cinnamon, black pepper, jam) on index card B.
3. Place the index card on top of the Argentine A.
4. Data observations about the experiment.
5. Put type of additions (boysenberry, Blackberry, Raspberry) on index card A.
6. Count the number of correct answers each student gives after 15 hours.
7. Put type of jam onto each index card.

Underline controls, circle changing variables, and box data collection.
```