Module 1: Shadows
5th 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 conclusions or the Conclusion Activity.

Activity Schedule:

There are no scheduling restrictions for this module.

Day 1: Technique/Observations/Variables (60 minutes)
Day 2: Question/Materials Page/Experimental Set-Up/Procedure (60 minutes)
Day 3: Results Table/Experiment/Graph/Conclusion Activity (60 minutes)
Day 4: Conclusion Activity/Conclusion/Question/Materials Page/Experimental Set-Up/Procedure (60 minutes)
Day 5: Results Table/Experiment/Graph/Conclusion (60 minutes)
Day 6: Conclusion/Poster Making (60 minutes)
Day 7: Poster Presentations (60 minutes)
Day 8: Conclusion Assessment/Tie to Standards (60 minutes)
*This schedule assumes the teacher has given the Conclusion Assessment before SciTrek comes on Day 1 of the module.

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 three subgroups, ~four students each, for the rest of the module. One volunteer is assigned to help each group (three subgroups). We find groups/subgroups work best when they are mixed levels and mixed language abilities.

NGSS Performance Expectation Addressed:

5-ESS1-2  Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky.
Learning Objectives:

1. Students will know shadow sizes are affected by the size of an object (height, width, and length) as well as the location of the light source (light distance, light height, and light angle).
2. Students will be able to determine the relative shadow size of two objects when there is one difference in either the object size, placement, or the location of the light source.
3. Students will know a conclusion is a claim supported by data.
4. Students will be able to classify a statement as claim, data, or opinion.
5. Students will be able to identify appropriate claims and data for a given data set.
6. Students will know they must only have one changing variable in order to draw a conclusion.
7. 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 three subgroups (~four students), after Day 1 of the module.

1. **Year 1**
   a. Classroom teacher leads a group (Role: Group Lead; this is referred to as a 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: Conclusion 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: Conclusion 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:

Note: We highly recommend that you complete the initial Conclusion Assessment prior to Day 1 of 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 1:
Have three floor spaces available for the students to perform the initial observation. Each group will need a ~2 ft x 4 ft floor space for the experimental set-up, as well as additional space for approximately ten students to sit. This ensures that students can begin the module as soon as SciTrek arrives. The desks/tables do not need to be moved into groups.

Day 2 - 6:
Have the students’ desks/tables moved into nine 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 - 5:
Have nine floor spaces available for students to perform experiments. Each subgroup will need a ~2 ft x 4 ft floor space for the experimental set-up as well as additional space for approximately three students to sit.

Day 7 - 8:
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 one or both of the following activities before SciTrek arrives:

1) Conclusion Assessment (highly recommend)
2) Technique Activity

Day 2:
If you would like to have more time for your students to design their experiments, you can do the example question/experimental set-up that is outlined in the introduction before SciTrek arrives.

Day 3:
If you would like to have more time for your students to perform their experiments, you can do one or both of the following activities:
1) Example graph outlined in the introduction before SciTrek arrives.
2) Conclusion Activity after SciTrek leaves.

Day 4:
If you would like to have more time for your students to redesign their experiments, you can finish the Conclusion Activity before SciTrek arrives.

Day 5:
If you would like to have more time for your students to perform their experiments and write conclusions, you can do the example conclusion before SciTrek arrives.

Day 7:
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 8:
If you would like more time for the Tie to Standards Activity, you may give the Conclusion Assessment before SciTrek arrives.

Materials Used for this Module:

1. Maglite Mini AAA LED Flashlight (Walmart Part Number: 551779062)
2. Colored light filters (Sammy’s Camera part number: orange (Lee Filters 105 (S105), green (Lee Filters 139 (S139), blue (Lee Filters 075 (S075)) cut to fit inside flashlight.
3. 152 cm/60 in flexible measuring tape (ETA hand2mind Part number: IN524)
4. Ruler (Office Depot Part Number: 2125472)
5. Masking Tape
6. Plastic Blocks (height: 2 cm, 3 cm, 4 cm, 5 cm, 6 cm, 7 cm, 8 cm, 9 cm, 10 cm; all blocks have widths of 7 cm and depths of 3 cm). (Spracher Engineering fabricates these blocks)
7. Support Stand with Rod (Spectrum Chemicals and Laboratory Products Part Number: 141-77765-E1) Rods (below; left) have masking tape marked with the height (every 5 cm, up to 60 cm). Bases (below; right) have masking tape marked with the direction of the flashlight beam and clamp. Bases also cite specifications for initial observation.
8. White Oil Cloth (Amazon sold by Fabric.com) cut into 20 in x 30 in pieces. (store flat)
9. Clamp (Fisher Scientific Part number: S99452) Clamps have been modified by tying a string (~70 cm of string length hanging down). The string is tied to the front of the clamp and secured in this position with masking tape. This allows students to determine the distance from the flashlight to the block.

10. Swing Arm Protractor (EAI Education: 502762)
11. Clipboard (OfficeMax Part Number: 21678980)

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: Technique/Observations/Variables

Note: We highly recommend that teachers complete the Conclusion Assessment prior to Day 1 of the module. The suggested times in the lesson plan below are assuming that the Conclusion Assessment was given prior to SciTrek arriving.

Schedule:

**Times if teacher gave assessment prior to SciTrek:**
- Introduction (SciTrek Lead) – 2 minutes
- Module Introduction (SciTrek Lead) – 3 minutes
- Technique (SciTrek Lead) – 7 minutes
- Observation Discussion (SciTrek Lead) – 4 minutes
- Observations (SciTrek Volunteers) – 25 minutes
- Variable Discussion (SciTrek Lead) – 5 minutes
- Variables (SciTrek Volunteers) – 12 minutes
- Wrap-Up (SciTrek Lead) – 2 minutes

**Times if SciTrek must give assessment:**
- Conclusion Assessment (SciTrek Lead) – 10 minutes
- Module Introduction (SciTrek Lead) – 3 minutes
- Technique (SciTrek Lead) – 5 minutes
- Observation Discussion (SciTrek Lead) – 4 minutes
- Observations (SciTrek Volunteers) – 20 minutes
- Variable Discussion (SciTrek Lead) – 5 minutes
- Variables (SciTrek Volunteers) – 9 minutes
- Wrap-Up (SciTrek Lead) – 2 minutes

Materials:

- (3) Volunteer Boxes:
  - □ Student nametags
  - □ (12) Student notebooks
  - □ Volunteer instructions
  - □ Picture of experimental set-up
  - □ Volunteer lab coat

- □ (2) Pencils
- □ (2) Wet erase markers
- □ Measuring tape (152 cm)
- □ (3) Rulers
- □ Masking tape
- □ Flashlight with colored filter (filter must be group color)

- □ Flashlight without filter
- □ (13) Protractors
- □ Clamp with string attached
- □ Ring stand base
- □ 5 cm Wooden block
- □ White plastic surface

- Other Supplies:
  - □ (3) Large group notepads
  - □ (3) Ring stand poles
  - □ (35) Clipboards

- Lead Box:
  - □ (3) Blank nametags
  - □ (3) Extra student notebooks
  - □ Lead instructions
  - □ Shadows picture packet
  - □ Picture of experimental set-up
  - □ Lead lab coat
  - □ Conclusion Assessments (if teacher did not take assessments then (35) assessments)
  - □ Time card
  - □ (2) Pencils
  - □ (2) Wet erase markers
  - □ (3) Markers (orange, blue, green)
  - □ (3) Measuring tapes (152 cm)
  - □ (3) Rulers
  - □ Masking tape

  □ Bag with (2) flashlights without filter, (3) colored filters (blue, orange, and green), and (4) AAA batteries
  □ (5) Protractors
  □ Clamp with string attached
  □ 5 cm Wooden block
  □ White plastic surface
**Notebook Pages and Notepad Pages:**

**TECHNIQUE**
Protractors

Protractors are used to measure and draw angles.

How to measure an angle using a protractor:
1. Line up the angle with the center point of the block and place the baseline parallel to the bottom of the block.
2. Move the swinging arm to point to the center of the flashlight.
3. The angle is the value on the outer clear scale, on the clear side of the swinging arm.

Identify the angle of the flashlight in relation to the box.

![Protractor Diagram]

**ANGLES:**
- 160°
- 90°
- 52°
- 136°

**OBSERVATIONS**

**Experimental Set-Up:**
- Block Height = 5 cm
- Block Width = 7 cm
- Block Length = 3 cm
- Light Angle = 60°
- Flashlight pointed and block

On the chart below, color the box that indicates the light distance and light height.

![Chart Diagram]

Teacher: ___________
Volunteer: ___________
Color: ___________
**OBSERVATIONS**

<table>
<thead>
<tr>
<th>Light Color:</th>
<th>Blue Light</th>
<th>White Light</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shadow Color:</td>
<td>Black</td>
<td>Black</td>
</tr>
<tr>
<td>Shadow Length: (Length of longest part of the shadow)</td>
<td>6.5 cm</td>
<td>6.5 cm</td>
</tr>
<tr>
<td>Shadow Width: (Width of widest part of the shadow)</td>
<td>10 cm</td>
<td>10 cm</td>
</tr>
</tbody>
</table>

Describe what happened during the experiment:

Changing the light color does not change the shadow length or width, but the white light shadow is easier to see than the blue light shadow.

**VARIABLES**

<table>
<thead>
<tr>
<th>Variable</th>
<th>How will changing this variable affect the shadows?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Block Height</td>
<td>The taller the block, the shadow length will ___________ and the width will ___________.</td>
</tr>
<tr>
<td>Light Distance</td>
<td>The farther the light distance, the shadow length will ___________ and the width will ___________.</td>
</tr>
<tr>
<td>Light Angle</td>
<td>The closer the angle is to 90°, the shorter the shadow length and the narrower the width.</td>
</tr>
<tr>
<td>Light Height</td>
<td>The higher the light height, the shadow length will be shorter and the width will be narrower.</td>
</tr>
<tr>
<td>Block Width</td>
<td>The wider the block, the shadow length will stay the same and the width will be wider.</td>
</tr>
</tbody>
</table>

Choose your own:
Preparation:

SciTrek Lead:
1. Get the Conclusion Assessments from the classroom teacher and put them in the lead box.
2. Make sure volunteers are writing their name and group color on the whiteboard.
3. Make sure volunteers are passing out nametags.
4. Make sure volunteers are setting up for the initial observation.
5. If the classroom has a document camera, ask the teacher to use it for the class question (front cover, student notebook), Technique Activity (page 2, student notebook), and block measurement pictures (page 1 and 2, picture packet). If the classroom does not have a document camera, then tape the poster-size notebook page to the front board and write the class question on the front board during the module introduction.

SciTrek Volunteers:
1. On the front whiteboard in the classroom, write your name and the color of the group (orange, blue, or green) you will be working with.
2. Pass out nametags.
   a. You may need to do this during the introduction. Quietly set each student’s nametag on their desk without talking to them. If names are not written on their desk, ask the classroom teacher or lead to help you when they are not talking with the class.
3. Have notebooks and protractors available to pass out.
4. Assemble the experimental set-up (shown in picture below as well as in color in the experimental set-up picture in your group box) on a spot on the floor where approximately ten students can sit.
   a. Attach the pole to the ring stand base by screwing them together.
   b. Attach the clamp to the ring stand pole at a height of 35 cm.
   c. Attach the flashlight with the colored filter to the clamp. Each group will have a filter that is the same color as the group. For example, the blue group will have a blue filter. Make sure the front of the clamp and the head of the flashlight are touching (see enlargement in picture below).
   d. Make sure the clamp and flashlight are pointing the correct way as indicated by the labels on the ring stand base and that the string is hanging down from the front of the clamp.
   e. Place the white plastic mat on the floor so that one of the short sides of the plastic is closest to the ring stand.
   f. Place the 5 cm block on the short side of the white plastic in the center.
   g. Place the protractor against the block with the swing arm pointed at 60°. Place the measuring tape under the protractor so that the zero mark of the measuring tape is touching the block. Use the masking tape to tape down the measuring tape. Make sure to not cover up the 25 cm mark on the measuring tape. The protractor will be laying on top of the measuring tape and the swing arm will be tracing the measuring tape.
   h. Use the measuring tape to position the ring stand so that the string connected to the clamp is hanging over the 25 cm mark of the measuring tape.
   i. Make sure the flashlight is in line with the protractor.
   j. Turn on the flashlight and adjust the clamp until the flashlight is pointed directly at the center of the block. When adjusting the flashlight, turn the head of the flashlight until the light forms the tightest possible circle on the center of the block. Then, turn off the light until the students have completed their observations of the experimental set-up.
   k. Place the three rulers on the white plastic.
   l. Place the flashlight without a filter and ten clipboards next to the experimental set-up.
How to Measure Lengths and Widths of Shadows

When measuring the length of the shadow, line up the 0 cm mark of a ruler with the front of the block (front of the white plastic). If your shadow length is longer than 30 cm, you will need to use the measuring tape instead of the ruler. The lead box has extra measuring tapes, if needed. Place another ruler (numbers side down) perpendicular to the first ruler at the edge of the shadow making an “L” with the two rulers. The shadow length can be read from the ruler which has its numbers exposed. The shadow length in the picture below on the left is 7 cm.

When measuring the width of the shadow, place two rulers (numbers side down) perpendicular to the short side of the white plastic on either side of the shadow. Measure the shadow width by placing a third ruler perpendicular to the two rulers, resulting in the rulers making an “H.” The shadow width in the picture below on the right is 8 cm.

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.

**Conclusion Assessment:**
*(10 minutes – Full Class – Given By Classroom Teacher Prior to SciTrek)*

“Before we start with the module, we will determine how your ideas on conclusions 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 students have written their name on their assessments.

For page 1 (top), read questions 1 and 2 aloud and give students time to answer each before moving on to the next question.

For page 1 (bottom), read the instructions to students. Then, read each of the statements aloud and have students circle whether the statement is an example of a claim, data, or opinion.

For page 2, tell students, “We will annotate or mark up the results table as a class.” Read the directions at the top of the page (on the results table, circle the changing variable(s), underline each control, and box information about data collection) aloud to students. Tell students, “When a variable is a changing variable, it is different for each trial and there will be a value written in each trial’s box, therefore, we will circle the variable.” Point to an example of a changing variable. “When a variable is a control, it is the same for each trial and there will be a value written in the trial 1 box and then an arrow through the remaining trials, therefore, we will underline the variable.” Point to an example of a control. Go through the table and for each variable and have the class say the word in parenthesis as you say the sentence. “Is the variable changing? (Yes/No) this makes the variable a (control/changing variable), therefore we should (underline/circle) it.” Then underline or circle the variable. When you get to the data section tell students, “This is a new section of the results table and this section contains the data from the experiment so everything in this section will be boxed.” Have students box the two pieces of data. Then have them individually decide if the group could make a conclusion.

Read step 1 of the instructions aloud to students (Identify the following statements as either CLAIM or DATA and write a C or D on the line.). Then, have students fill in whether they think statement “a” is a claim or data by writing a C or D on the line. Tell students, “This part is similar to page 1 of the assessment.” Read step 2 of the instructions aloud to students (Look at the results table and circle if the statement is a correct claim, correct data, or incorrect. Statements are INCORRECT if the statement does not agree with the results table or has not been tested). Point to the results table and have students circle whether they think statement “a” is correct claim, correct data, or incorrect claim or data. Once students have completed statement “a,” read statement “b” aloud and tell students, “Write a C or D on the line depending on whether you think the statement is a claim or data.” After about 15 seconds tell students,
“Now look at the results table and circle whether the statement is a correct claim, correct data, or incorrect.” Repeat the process for statements c-e.

For page 3, repeat the process including annotating the results table as a class.

For page 4, question 8, tell students, “You are going to write a conclusion, or summarize what a scientist learned, by collecting the following data.” Point at the results table. Read the directions aloud to students and give them a few minutes to try and write a conclusion. Most students will struggle with this. Reassure them it is okay and they can just guess or leave it blank. When students are finished, collect the assessments and verify students’ names are written on top.

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

Have volunteers pass out a notebook to each student.

Have students fill out their name, teacher’s name, group color (color of their name on their nametag: orange, blue, or green), and their volunteer’s name (volunteers’ names should be written on the board next to the group color they will be working with) on the front cover of their notebooks. Students will leave the subgroup number and class question blank. If a student does not have a nametag, only have them fill out their name and teacher’s name on the cover of their notebook. They will be placed in a group when the class divides into groups for observations and can fill out their group color and volunteer at that point.

Tell the class, “We are going to investigate shadows.” Ask the class, “What are shadows and what causes them?” By the end of the conversation, make sure students understand that shadows are formed when an object blocks light causing a dark area where the light would have been if the object was not there.

Ask the class, “Can one object make different sized/shaped shadows?” By the end of the conversation, make sure students understand the shadow size/shape can change depending on the light source.

Tell students, “For this module, we will be exploring shadows to learn more about what causes shadows’ sizes to change. Therefore, the question that we will be exploring as a class is ‘What variables affect shadows?’” Write this question on the front page of the class notebook under the document camera and have students copy the question onto the cover of their notebooks.

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

Have volunteers pass out a protractor to each student.

Tell the class, “We will be working with light sources for this module and we will need to be able to describe the location of the light source. One tool that scientists use to do this is a protractor.” Show the students a protractor. Have students turn to page 2 of their notebooks and place the class notebook under the document camera. Review the parts of the protractor while pointing to each part on an example protractor.

Tell students, “The outer clear scale shows the angle measurement from 0°-180° and the inner colored scale shows the angle measurement from 180°-0°. For this module, we will only use the outer scale. The swing arm is the part of the protractor that moves and is used to determine the angle of an object in relation to another object. The angle is read off the clear side of the swing arm regardless of the scale.
used. The origin of the protractor is where the swing arm is attached and should be placed at the center of one of the two objects. In our experiment we will place the origin on the center of a block. The baseline is where the start of the inner and outer scale meets and will be lined up parallel to the base of the reference object (block). To measure an angle, the protractor is put on the reference object and the swing arm is pointed at the other object. For this module, the other object will be the light source. The angle between the light and the block can then be read from the outer scale on the clear side of the swing arm.”

A picture of these parts is shown below.

Tell students, “We are now going to determine the angles of a flashlight relative to a block.” As a class, complete question 1 together. Then, have students complete the next three questions on their own. Once the majority of students are finished, go over the answers with the students. Tell students, “It is okay if your answers differ by up to 3° from the angle in the class notebook” (see example notebook below). Volunteers should walk around and assist struggling students as they complete page 2. As soon as students have completed page 2, have volunteers collect the protractors.
Tell students, “Now that you know how to use a protractor to measure angles, you will be able to use these skills to determine what angle the light is coming from to create a shadow.”

**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 make observations of a shadow made from two different light colors. We will need to be able to compare our data with one another, therefore, we will all need to measure the length and width of the shadows the same.” Put page 1 of the picture packet under the document camera (below; left).

Demonstrate how to measure the shadow length. Line up the 0 cm mark of a ruler with the front of the block (front of the white plastic). Place another ruler (numbers side down) perpendicular to the first ruler at the edge of the shadow, making an “L” with the two rulers. The shadow length can be read from the ruler which has its numbers exposed. The shadow length for this example is 7 cm.

Demonstrate how to measure the shadow width. Place two rulers (numbers side down) perpendicular to the short side of the white plastic on either side of the shadow. Measure the shadow width by placing a third ruler perpendicular to the two rulers, resulting in the rulers making an “H”. The shadow width in this example is 8 cm.

Turn to page 2 of the shadows picture packet (above; right) and walk students through measuring the shadow length and width. For this example, you should measure the shadow length to be 7 cm and the shadow width to be 14 cm.

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 and their notebook.
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.

**Observations:**
(25 minutes – Groups – SciTrek Volunteers)

Once students come over to your group, have them sit in boy/girl fashion on the floor around the set up. Verify the floor is set up as described in the Set-Up Section. Pass out a clipboard to each student and have them turn to page 3 of their notebook.

As a group, have students generate approximately six observations about the experimental set-up before you turn on the flashlight. Observations should be recorded in the group notepad under “Experimental Set-Up” or by circling the light position on the chart and then copied by students into their notebooks. Observations about the experimental set-up should be recorded in bullet points to save time. Make sure to record the following observations about the experimental set-up: block dimensions (height – 5 cm, width – 7 cm, length – 3 cm), and light angle (60°). Show students how to fill in the chart which shows the light distance (25 cm) and light height (35 cm), making sure to shade in the box that represents their set-up. This should take you no longer than 10 minutes. An example filled out experimental set-up for the initial observation is shown below.

![Experimental Set-Up Example](image)

Have students turn to page 4 of their notebooks while you turn to page 2 on the group notepad. Turn the flashlight on and point the light directly at the center of the block and then focus the light in as small of a circle as possible. The light color should be the same color as your group color (blue group will have a blue light source). Have students fill in the light color at the top of the chart. They should then fill in all of the observations for the colored light portion of the chart. For the shadow length measurement, have
students measure from the front of the block to the longest end of the shadow. For the shadow width measurement, have students measure the widest part of the shadow. As students make observations, record them in the group notepad. Change the flashlight to the flashlight without the colored filter, which will produce white light and repeat the observation process.

In the example notebook, the shadow colors for both the colored light and the white light were recorded as black. Some students may notice that the shadow from the colored light does have a slight color to it (orange light: blue shadow, blue light: black shadow, and green light: pink shadow). Do not bring this up if students do not notice this. However, students are welcome to record this if it is noticed. For example, students can record that for an orange light a black/blue shadow was observed.

If there is additional time, have students write a summary of what happened to the shadow when the color of the light changed. Have students focus on comparing and contrasting the two shadows.

An example filled out initial observations is shown below.

<table>
<thead>
<tr>
<th>OBSERVATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Light Color:</strong></td>
</tr>
<tr>
<td>Shadow Color:</td>
</tr>
<tr>
<td>Shadow Length: (Length of longest part of the shadow)</td>
</tr>
<tr>
<td>Shadow Width: (Width of widest part of the shadow)</td>
</tr>
</tbody>
</table>

Describe what happened during the experiment:

Changing the light color does not change the shadow length or width, but the white light shadow is easier to see than the blue light shadow.

Variable Discussion:

(5 minutes – Full Class – SciTrek Lead)

Ask the class questions to review the experiment that they carried out, as well as what they learned about how changing the light color affects the shadow. Make sure by the end of the discussion, students have identified that changing the light color changes the color they see surrounding the shadow’s outline, but it does not change the shadow’s size or shape. Ask students, “Which shadow was easier to see, the shadow generated from the colored light or the white light?” They should reply, “The shadow generated from the white light.” Ask students, “Which light source do you think we should use for other experiments and why?” Possible student response: the white light because these shadows are easier to measure and that the color of light does not affect the shape/size of the shadow.
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?**
  - Light color.

- **Do you think that there are multiple variables that will affect the size of the shadow?**
  - Multiple variables might affect the size of the shadow.

Explain that this is why we will need to work as a class to answer the class question: “What variables affect shadows?”

Tell the class, “You are going to think about variables in the experiment that you could change in order to help us answer the class question. In addition to generating variables, you should think about how/why these variables might affect the outcome of the experiment.” Ask the class, “What do you think is a variable that might affect the size (length and width) of the shadow?” Then, have them tell you how/why they think that variable would affect the size of the shadow. Probe them on how they would design an experiment to test if this variable affected the shadow. 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:** block height  
*Why might this variable affect the shadow?* Shadows are caused by the object blocking light therefore different sized blocks might block different amounts of light.

*How would you test this variable?* Get blocks that are different heights and measure the shadow length.

*Prediction:* The taller the block, the longer the shadow.

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

**Note:** If you are running behind and there are less than 5 minutes remaining, generate variables as an entire class instead of in groups.

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

As a group, generate a variable and make a prediction about how it will affect the length and width of the shadow. Encourage and challenge students to explain why they think their prediction is correct and how this variable will affect the shadow. If needed, you can write down a sentence frame for students to use. Repeat this process two 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 additional variables, make predictions about how different values of these variables will affect the shadow, 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 shadows during the class discussion.
Wrap-Up:
(2 minutes – Full Class – SciTrek Lead)

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

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

Clean-Up:

1. Collect notebooks with attached nametags.
2. Take ring stand apart.
3. Put ring stand pole and clipboards back into their containers.
4. Place all other materials into your group box and bring them back to UCSB.
Day 2: Question/Materials Page/Experimental Set-Up/Procedure

Schedule:

Introduction (SciTrek Lead) – 13 minutes
Question (SciTrek Volunteers) – 10 minutes
Materials Page (SciTrek Volunteers) – 7 minutes
Experimental Set-Up (SciTrek Volunteers) – 8 minutes
Procedure (SciTrek Volunteers) – 19 minutes
Wrap-Up (SciTrek Lead) – 3 minutes

Materials:

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

(3) Materials pages (subgroup color & number indicated)

Volunteer lab coat
(2) Pencils

(2) Red pens

Notepad

Lead Box:
- (3) Blank nametags
- (3) Extra student notebooks
- Lead instructions
- Shadows picture packet
- Lead lab coat

(3) Materials pages

Time card
(2) Pencils

(2) Red pens

(2) Wet erase markers

(3) Markers (orange, blue, green)

Notepad

(2) Example blocks of different heights

Notebook Pages:

**Experimental Considerations:**

1. You will only have access to the materials on the materials page.
2. You will only have access to one flashlight with visible light and the light must be focused and pointed directly at the center of the block.
3. All objects will be rectangular blocks and you will only be able to change one dimension of the block.

Changing Variable(s)/Independent Variable(s):

You will get to perform two experiments. For your first experiment, decide which variable(s) (less than three) that you would like to test. For each changing variable that you select, discuss with your subgroup why you think that variable will affect the shadow.

Changing Variable 1: Light Distance
Discuss with your subgroup how you think changing variable 1 will affect the shadow.

Changing Variable 2 (optional):
Discuss with your subgroup how you think changing variable 2 will affect the shadow.

Changing Variable 3 (optional):
Discuss with your subgroup how you think changing variable 3 will affect the shadow.

What will you measure? (circle one)

- [ ] Shadow length
- [ ] Shadow width

**QUESTION**

Question our subgroup will investigate:

- If we change the light distance, light angle, and block width, what will happen to the shadow length?

Get a materials page from your SciTrek volunteer and fill it out before moving onto the experimental set-up.
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 for the question (page 6, student notebook), materials page (lead box), and experimental set-up (page 7, student notebook). If the classroom does not have a document camera, then tape the poster-size notebook pages to the front board.
3. Have two example blocks of different heights to show during the introduction.

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 three materials pages, each filled out with a subgroup number (1, 2, or 3) and your group’s color to give to subgroups after they complete their question.
3. Have a red pen available to approve students’ question, experimental set-up, and procedure (pages 6, 7, and 8).

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:**
* (13 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?” Possible student response: we did an experiment in which we changed the light color (colored and white light) and observed the shadow that a block cast. We learned that the color of the light does not affect the size of the shadow, but it does affect how clearly we see the shadow’s outline. We also generated variables that might affect shadows. Ask the class, “What is the class question we will be investigating?” Students should reply, “What variables affect shadows?”

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 shadows?” 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 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(s) that they plan to explore. They will then fill out their materials page, which will allow them to determine their experimental set-up. The experimental set-up will help them generate a procedure, or a set of steps to conduct an experiment. 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. You will only have access to one flashlight with white light and the light must be focused and pointed directly at the center of the block.
3. All objects will be rectangular blocks and you will only be able to change one dimension of the block.

When you tell students experimental consideration 3, show students the two example blocks and tell them, “Two of your block dimensions must be 7 cm and 3 cm, but you can rotate your block so that you will be able to choose to change either the height, width, or length of the block.”

Tell students, “We are now going to generate an example question/experimental set-up together. I will write it in the class notebook so 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 example question/experimental set-up in their notebooks.

Tell students, “For the example experiment, the changing variables will be light distance and block length.” Then, write down the changing variables on the class notebook (page 6, student notebook) under the document camera. Tell students, “When you are going through this process in your subgroups, you may select one, two, or three changing variables.”
**Note:** It is important that you select the changing variables for the example experiment to have one variable about the block and one variable about the light. The materials page for this module is complex and picking these two variables allows you to go over how to fill out the page for any changing variable.

Tell students, “You will now select whether you will measure the shadow length or width. If you think you know what will happen to one of these, you might select the opposite to measure. For example, if I thought I knew how block height affected the length of the shadow, I might decide to measure the width of the shadow.” Then, circle the measurement that will be taken for the example experiment.

Show students how to insert the changing variables and what they plan to measure/observe into the question frame to find the question that will be investigated, “If we change the light distance and block length, what will happen to the **shadow length**?”

![Question Frame Example](image)

Tell students, “Once you have determined your question and have approval, your volunteer will give you a materials page for determining the values of your changing variable(s) 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 light height was 45 cm for all of the trials, then one of their controls would be light height. These controls and control values can be different from the original experiment they conducted on Day 1, but must remain constant throughout all the trials that they do for this experiment.

Show students the materials page (lead box) 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 variables that are changing variables, choose 4 values and write the trial letter next to each value.). Read the general materials to students, ask them if they need each one, and check the box when they say yes. Go through the remaining items on the materials page. If a variable is a control, then choose (do not let...
students choose) a single value, such as the original value (Ex: “60°” for “light angle”). Assign each control value to a student and tell them, “You are in charge of remembering this control and its value to help when filling out the experimental set-up.” For variables that are changing variables, allow students to select the values. Write the trial letter next to each selected value. Ask students, “Do we want a narrow or wide range of values for the changing variables and why?” Guide students through selecting a wide range of values for both changing variables. If they choose a value contrary to their proposed experimental design, question them on their reasoning. For example, if they said they wanted to use a wide range of block lengths and they picked 4 cm, 3 cm, 2 cm, and 5 cm, ask them, “Would the selected values allow us to best answer the question?” Allow them to change their values if needed. Assign the changing variable values to the students who chose them.

When selecting the block, remind students that only one of the block dimensions can be a changing variable. Tell them, “If one of the block dimensions is a changing variable, then, this needs to go on the first line under the block on the materials page. If all of the block dimensions are controls, you can select any block dimension you would like, and put it on the first line. You can then select which other block dimension will be 7 cm and which will be 3 cm.”

When selecting the light location (light distance and light height) show students how to use the chart. Tell them, “You can select any light location as long as it is not greyed out.” Show them how to fill out the section of the materials page above the chart. If one or both of light distance and light height are controls (such as for light height in the example experiment) show them how to write their selected value on the line. Then go to the chart and circle the row and/or column that corresponds to the selected value(s). If, on the other hand, one or both of light distance and light height are changing variables (such as for light distance in the example experiment), inform them to leave the line blank. Then read students the instructions directly above the chart and ask the following questions:

If you have no circles you can select/mark any value that is not greyed out.

Ask students, “Is this our case?” They should reply, “No.” Tell students, “If this was your case, you could put your trial letters in any four squares that are not greyed out.”

If you have one circle you can only select/mark values within that circle.

Ask students, “Is this out case?” They should reply, “Yes.” Have students select four values within the circle that are spread out, and mark them on the materials page with the trial letters.

If you have two circles you can only select the values that are circled by both circles.

Ask students, “When did we see something like this?” They should remember this is what they did on the first day when they were determining the light distance and height of the white and colored flashlights.

When selecting light angle(s) they can pick any angle(s) between 20° and 160°. They will circle the angle(s) they will be using in their experiment. If the angle is not on the picture, they can write in the desired angle in the appropriate spot and then circle it.
Tell students, “Once you have completed your materials page, you will fill out your experimental set-up (page 7, student notebook). First, you will fill out the information on the changing variable(s).” Ask students, “What are the changing variables for the example experiment, and what values did we select?” Then, fill in the values for trials A and B only. Tell them, “Second, you will fill in information about the controls.” Draw an additional control line under the existing control list. Ask students, “What is one of the controls and its value for the example experiment?” Show students how to record the control on the left side of the slash (Ex: light color) and the value of that control on the right side of the slash (Ex: white). There are six possible variables to choose from on the materials page. If a subgroup changes three variables, they 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 may need to generate two additional variables that do not come from the materials page.” Lead students to realize this should be surface/white plastic and block material/plastic.

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 you think no other subgroups are exploring. Once your subgroup has completed your experimental set-up, you should raise your hands and get it approved by your volunteer.” Below is an example of what should be filled out for the experimental set-up in the class notebook. Note that several sections are left blank, but this will not be the case for the students’ notebooks.
Tell students, “After you finish your experimental set-up, you will write a procedure for your experiment that you will be able to follow next time. When writing a procedure, you should write all values of your controls and changing variable(s) as well as what data will be collected.” Show students the example procedure step on page 8 of their notebook (Place block that is 7 cm wide, 3 cm long and A) 2 cm, B) 5 cm, C) 8 cm, and D) 10 cm high on white plastic.). Tell students, “Once your procedure is completed, you will get it approved by a volunteer.”

If needed, have students move into their subgroups. Place the example question (page 6, class notebook) under the document camera so students may refer to it as they design their experiments. As subgroups move onto their experimental set-up, put the example experimental set-up (page 7, class notebook) under the document camera.

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

Have subgroups decide what changing variable(s) they want to explore for their first experiment. If they only have one changing variable, do not encourage them to have more. If they have two/three changing variables, do not encourage them to have fewer. Students will analyze their data and then perform an additional experiment to correct any mistakes that they made on their first experiment.

After subgroups have decided on their changing variable(s), have them decide and circle what they will measure. They can then 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: 
(7 minutes – Subgroups – SciTrek Volunteers)

Have subgroups underline their controls and circle their changing variable(s) on the materials page. Then, have them use the materials page to determine the values for their controls and changing variable(s). For the changing variable(s) 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(s)?, Will these values make it easier or harder to answer your question?”

Make sure students have picked light distances and light heights that are within the limitations given on the materials page. In addition, ensure students have no more than one block dimension changing. An example filled out materials page is shown below.
Experimental Set-Up:
(8 minutes – Subgroups – SciTrek Volunteers)

Have subgroups use their materials page to fill in their experimental set-ups on page 7 of their notebooks. For subgroups that have three changing variables, there will be two control blanks that will not come from the materials page, students should put surface/white plastic and block material/plastic. 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. An example filled out experimental set-up is shown below.
Procedure:
(19 minutes – Subgroups – SciTrek Volunteers)

After each subgroup has filled out their experimental set-up, they can start on their procedure (page 8, student notebook). Make sure that students within the same subgroup are collaborating to write the procedure. Keep procedures as brief as possible while still conveying the pertinent information about the experiment (control values, changing variable values, and what data they will collect). An example step for a subgroup that had block height as a changing variable would be, “Place block that is 7 cm wide, 3 cm long, and A) 2 cm, B) 5 cm, C) 8 cm, and D) 10 cm tall on the white plastic.” Some subgroups may struggle with writing a procedure. You can have these subgroups dictate each step while you transcribe them onto a notepad found in your group box. Give this sheet to the students to copy into their notebooks. Once students have finished, they should raise their hand and get their procedure approved by their volunteer. An example filled out procedure can be seen below.
If there is time, have your subgroups fill out the variables and prediction section of the results table (see Day 3 for directions and example page).

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

If there is time, have one student from each subgroup share what question they will investigate. Tell students, “Next session, you will start your experiments. All of your experiments will help us answer the class question: What variables affect shadows?”

**Clean-Up:**

1. Collect notebooks with attached nametags.
2. Place all materials into your group box and bring them back to UCSB.
Day 3: Results Table/Experiment/Graph/Conclusion Activity

Schedule:

Introduction (SciTrek Lead) – 8 minutes
Results Table (SciTrek Volunteers) – 3 minutes
Experiment (SciTrek Volunteers) – 22 minutes
Graph (SciTrek Volunteers) – 10 minutes
Conclusion Activity (SciTrek Lead) – 15 minutes
Wrap-Up (SciTrek Lead) – 2 minutes

Materials:

(3) Volunteer Boxes:
- ☐ Student nametags
- ☐ Student notebooks
- ☐ Volunteer instructions
- (3) Ziploc bags with the following: (labeled with subgroup number)
  - ☐ Measuring tape (152 cm)
  - ☐ Protractor

(2) Red pens
- ☐ Picture of Experimental Set-up
- ☐ Volunteer lab coat
- ☐ (2) Pencils

(3) White plastic surfaces
- ☐ (2) Red pens
- ☐ Masking tape
- ☐ Notepad

Other Supplies:
- ☐ Box with 9 ring stand bases, 9 flashlights, and 9 clamps with string attached
- ☐ Tube with 9 ring stand poles
- ☐ (35) Clipboards

Lead Box:
- ☐ (3) Extra student notebooks
- ☐ Lead instructions
- ☐ Shadows picture packet
- ☐ Picture of Experimental Set-up
- ☐ Lead lab coat
- ☐ Time card

- ☐ (2) Pencils
- ☐ (2) Red pens
- ☐ (2) Wet erase markers
- ☐ Notepad
- ☐ (6) Rulers
- ☐ (2) Masking tapes
- ☐ Example block (any size)

- ☐ Bag 1: lead shadows supplies ((3) measuring tapes (152 cm), (2) flashlights, (4) AAA batteries, (2) protractors, (2) clamps with string attached, (9) blocks – one of each size)
- ☐ White plastic surface

Materials:

(3) Volunteer Boxes:
- ☐ Student nametags
- ☐ Student notebooks
- ☐ Volunteer instructions
- (3) Ziploc bags with the following: (labeled with subgroup number)
  - ☐ Measuring tape (152 cm)
  - ☐ Protractor

(2) Red pens
- ☐ Picture of Experimental Set-up
- ☐ Volunteer lab coat
- ☐ (2) Pencils

(3) White plastic surfaces
- ☐ (2) Red pens
- ☐ Masking tape
- ☐ Notepad

Other Supplies:
- ☐ Box with 9 ring stand bases, 9 flashlights, and 9 clamps with string attached
- ☐ Tube with 9 ring stand poles
- ☐ (35) Clipboards

Lead Box:
- ☐ (3) Extra student notebooks
- ☐ Lead instructions
- ☐ Shadows picture packet
- ☐ Picture of Experimental Set-up
- ☐ Lead lab coat
- ☐ Time card

- ☐ (2) Pencils
- ☐ (2) Red pens
- ☐ (2) Wet erase markers
- ☐ Notepad
- ☐ (6) Rulers
- ☐ (2) Masking tapes
- ☐ Example block (any size)

- ☐ Bag 1: lead shadows supplies ((3) measuring tapes (152 cm), (2) flashlights, (4) AAA batteries, (2) protractors, (2) clamps with string attached, (9) blocks – one of each size)
- ☐ White plastic surface
**RESULTS**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Trial A</th>
<th>Trial B</th>
<th>Trial C</th>
<th>Trial D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light Color</td>
<td>White</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Block Height</td>
<td>7 cm</td>
<td>3 cm</td>
<td>2 cm</td>
<td>10 cm</td>
</tr>
<tr>
<td>Block Width</td>
<td>7 cm</td>
<td>2 cm</td>
<td>10 cm</td>
<td>4 cm</td>
</tr>
<tr>
<td>Block Length</td>
<td>3 cm</td>
<td>3 cm</td>
<td>1 cm</td>
<td>4 cm</td>
</tr>
<tr>
<td>Light Distance</td>
<td>25 cm</td>
<td>60 cm</td>
<td>10 cm</td>
<td>45 cm</td>
</tr>
<tr>
<td>Light Height</td>
<td>25 cm</td>
<td>30°</td>
<td>90°</td>
<td>20°</td>
</tr>
<tr>
<td>Surface Material</td>
<td>White</td>
<td>Plastic</td>
<td>Plastic</td>
<td>Plastic</td>
</tr>
<tr>
<td>Predictions</td>
<td>Trial A</td>
<td>Trial B</td>
<td>Trial C</td>
<td>Trial D</td>
</tr>
<tr>
<td>Trial A</td>
<td>B</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trial B</td>
<td></td>
<td>S</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trial C</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Trial D</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Data</th>
<th>Trial A</th>
<th>Trial B</th>
<th>Trial C</th>
<th>Trial D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Measurement</td>
<td>9.5 cm</td>
<td>3 cm</td>
<td>30 cm</td>
<td>10 cm</td>
</tr>
</tbody>
</table>

**SCIENTIFIC PRACTICES**

1. Directions Fill in the missing definition:
   - **Conclusion:** a claim supported by data
     - **Claim:** A statement that can be tested. The explanation of the data, the first part of a conclusion.
       - Examples:
         - Donuts have more fat than toast.
         - Evidence collected from experiment(s) (measurements or observations), the second part of a conclusion.
         - Donuts have 5 grams of fat while a serving of toast has 2 grams of fat.

2. Directions: Circle if the statement is a CLAIM, DATA, or an OPINION.
   a. Out of 30 people only 3 can ride a unicycle.
   b. Puppies are cute.
   c. People who got 5 hours of sleep showed improvement.
   d. Instead of syrup, starbucks, and frosted cakes.
   e. The fastest land animal in the world is the cheetah.
   f. When 2 ml of vinegar was mixed with 2 g of sugar, 100 grams of gas was produced.
   g. The more simple the flower the more bees on the flower.
Preparation:

SciTrek Lead:
1. Make sure volunteers are setting out notebooks.
2. Make sure volunteers are setting up for the experiment.
3. If the classroom has a document camera, ask the teacher to use it to show the filled-out results table (page 3, picture packet), graph (page 10, student notebook), Conclusion Activity (page 11, student notebook), and block measurement picture (1, picture packet). If the classroom does not have a document camera, then tape the poster-size notebook pages to the front board.
4. Have example block available to show students during the introduction.

SciTrek Volunteers:
1. Set out notebooks/nametags.
2. Set-up experiments in separate areas on the floor.
   a. Put the ring stands together and attach the flashlight to the clamp. Make sure the flashlight is flush with the front of the clamp. Place the clamp at the lowest place on the ring stand to allow students to put the clamp at the appropriate height(s) when they do their experiment.
   b. Place bags with supplies (labeled with subgroup number), white plastics, and ring stand/clamp set-ups in three unique spots on the floor along with four clipboards.

   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.

How to Measure Lengths and Widths of Shadows

When measuring the length of the shadow, line up the 0 cm mark of a ruler with the front of the block (front of the white plastic). If your shadow length is longer than 30 cm, you will need to use the measuring tape instead of the ruler. The lead box has extra measuring tapes, if needed. Place another ruler (numbers side down) perpendicular to the first ruler at the edge of the shadow making an “L” with the two rulers. The shadow length can be read from the ruler which has its numbers exposed. The shadow length in the picture below on the left is 7 cm.

When measuring the width of the shadow, place two rulers (numbers side down) perpendicular to the short side of the white plastic on either side of the shadow. Measure the shadow width by placing a third ruler perpendicular to the two rulers, resulting in the rulers making an “H.” The shadow width in the picture below on the right is 8 cm.
**Introduction:**
(8 minutes – Full Class – SciTrek Lead)

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

Ask the class, “What is the class question we are investigating?” Students should reply, “What variables affect shadows?”

Tell students, “Today you will conduct your experiment to answer this question. However, before you start your experiment, you need to fill out the results table (some students might have completed this in the previous session).” Put the filled-out results table (page 3, picture packet, shown below) under the document camera. Tell students, “You should first underline controls, circle changing variables, and box information about data collection. For controls, you will write the control value in the trial A box and then draw an arrow through the remaining trials’ boxes, and for the changing variable(s), you will write the changing variable value in each box.” Show students both cases on the filled-out results table. Tell students, “Once you have filled out your results table, you will make predictions about which trial will produce the biggest/smallest shadow. You will write a ‘B’ in the box of the trial that you think will produce the biggest (longest or widest) shadow, and an ‘S’ in the box of the trial that you think will produce the smallest (shortest or skinniest) shadow. If you think all trials will produce the same size shadow, you will write ‘same’ over all boxes. Once finished, you can raise your hands and you will be dismissed to go to the spot on the floor that has your experimental supplies.”

Tell students, “Once you have collected your data, you will display your measurements on a graph (page 10, student notebook).” Show them how to make a graph using the example data, but make sure they DO NOT copy this data into their notebooks; they will graph their own data. Take out the example results table, page 3 of the picture packet (shown below, left), and put it under the document camera. Also, have the class notebook open to page 10. Tell students, “For this example experiment, the question was, ‘If we change the block height and light distance, what will happen to the length of the shadow?’” Point to the checklist at the top of page 10 of the class notebook and tell students, “In order to make a graph, you will need to follow the checklist shown on this page.”
Go through the checklist and use the results table in the picture packet to show the students how to set up the graph and plot the two data points on the graph.

Set up your graph. (Check off the steps as you complete them.)

Tell students, “First we need to set up the graph before we can plot the data.”

☐ Label the y-axis (vertical) with what you measured, including units (Ex: shadow length (cm)).
   Tell students, “Since the question is about shadow length, I will graph shadow length.”
   Write “shadow length (cm)” on the y-axis of the graph.

☐ Determine an appropriate scale which will allow you to graph all of your data points and write the numbers on the given lines.
   Tell students, “We need to make sure that the longest shadow can be plotted on the graph.” Have the students refer to the results table in the picture packet and ask them to identify the longest shadow that was measured (47 cm). Then ask, “Would we be able to fit this shadow length on the graph if we counted by ones?” Students should reply, “No.” Then ask, “What should we count by in order to make sure that the longest shadow’s length will fit on the graph?” Make sure that the class reaches the consensus of fives.
   When students make their own graphs, they should only count by ones, twos, or fives.
   Number the y-axis, making sure that they know to start counting at zero. Make sure you completely fill out the y-axis numbers to the top of the graph and do not stop numbering after you have passed the largest number that you will graph.

☐ Label the x-axis (horizontal) with your changing variable(s) #1, #2, and #3 (Ex: block height).
   Changing variable #2 and #3 will only be filled in if you have 2 or 3 changing variables.
   Ask students, “What are the changing variables in this experiment?” Students should reply, “Block height and light distance.” Record “block height” as changing variable #1 and “light distance” as changing variable #2.

☐ On your results table, label your measurements from 1 to 4, with 1 being the trial with the smallest measurement and 4 being the trial with the largest measurement.
   Tell students, “Graphs are used to see how changing variables affect the measurements. One way to make it easier to find patterns is to graph the data in increasing order.” Put the example results table (page 3, picture packet, shown below on the left) under the document camera and have students help determine the order that the trials will be graphed (A, C, D, then B) and write the appropriate number by each trial. This is the step that both students and volunteers often forget to do, so emphasize its importance when completing it with the class.

Plot your data in increasing order.
   Tell students, “Now that you have determined the order in which you will graph your data, you need to plot your data in increasing order. To do this, there are a few steps that you need to follow.”

☐ Write the changing variable value(s) (Ex: 5 cm) for the trial that you labeled 1 under the first column.
   Ask students, “Which trial was labeled 1?” Students should reply, “Trial A.” Then, ask them, “What should I write next to block height and light distance for the first column?”
   Write “5 cm” for block height and “10 cm” for light distance in the class notebook.

☐ Graph your data for that trial and write the measurement above the bar.
Ask students, “What shadow length should we graph for the first column?” Students should reply, “5 cm.” Put your finger at zero and tell students, “Tell me when to stop once I reach the appropriate level.” Once you have reached the level, draw the line, write the numerical value over the line, and quickly shade below the line. Tell students, “Look at how fast I filled in the chart. I challenge you to fill in your graph faster than me when you graph your own data!”

☐ Repeat the process for the other trials.

Ask students, “What are the values for the changing variables for the trial we will graph next?” Students should reply, “3 cm for block height and 45 cm for light distance.” Write these in the next column. Ask students, “What is the shadow length for this trial?” Students should reply, “23 cm.” Have students help you identify where 23 cm is, draw a line, and write the numerical value over the line. Tell students, “I will only graph the first two data points, but in your subgroups, you will graph all four points.”

Remind students how we define the block dimensions. Show students the example block. Place the block on the edge of the picture packet and tell them, “The picture packet will represent the white plastic and the light source would be in front of the block.” Ask students, “What do we call the block dimension going up?” Students should reply, “Height.” Ask students, “What do we call the block dimension going across the front of the white plastic?” Students should reply, “Width.” Ask students, “What do we call the block dimension going away from the light?” Students should reply, “Length.” Show students they can look at the picture at the top of their results table if they forget which dimension is which.

Put page 1 of the picture packet under the document camera and review how to measure the length and width of the shadow. Have students identify, by raising their hands, if they are measuring shadow length. Then, tell those students, “When measuring the length of the shadow, you will line up the 0 cm mark of a ruler with the front of the block (front of the white plastic). You will then place another ruler (numbers
side down) perpendicular to the first ruler at the edge of the shadow, making an ‘L’ with the two rulers.” Have students identify by raising their hands if they are measuring shadow width. Then, tell those students, “When measuring the shadow width, you will place two rulers (numbers side down) perpendicular to the short side of the white plastic on either side of the shadow. You will then measure between the two rulers with a third ruler to find the shadow width resulting in the rulers making an ‘H’ with the three rulers.”

Tell students, “You will now fill out your results tables and start your experiment. When you are done with your experiment, you can graph your results.”

Results Table:
(3 minutes – Subgroups – SciTrek Volunteers)

Have students underline the variables that are controls, circle the variable(s) that is/are their changing variable(s), 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(s), they should write the value(s) in each trial’s corresponding box.

When students have finished, have them make predictions about the shadows. Have them write “B” in the box of the trial they think will produce the biggest shadow length/width and “S” in the box of the trial they think will produce the smallest shadow length/width. They will leave two of the boxes empty. If they think all trials will produce the same shadow length/width, have them write “same” over all of the boxes. It is okay if the students in a subgroup have different predictions. An example filled out results table is shown in the Experiment Section below (left).

Experiment:
(22 minutes – Subgroups – SciTrek Volunteers)

Once subgroups have finished their results tables, show them where their supplies are. If students are missing any of their experimental materials, the lead box has extra materials. If students have a fixed light angle, you can give them masking tape from your group box to tape down their measuring tape so it does not move. For these students, the measuring tape should go under the protractor. For subgroups changing light angle, have the protractor’s swing arm in the correct orientation and then put the measuring tape on top of the protractor. Do not tape down the measuring tape because it will be moved for the next trial. Remind students to make sure that the flashlight is in line with the protractor and the string is hanging down from the front of the clamp.

Have students show you their set-up for their first trial before taking any measurements. When checking students’ set-ups, verify they have their block in the correct orientation. If students have chosen to change the light angle, and the shadow becomes too wide for the white plastic, the plastic may be moved to see the entire shadow. However, make sure that the direction the block faces does not change when the white plastic is moved. If the shadow is longer or wider than the ruler, have students use a measuring tape found in the lead box.

Make sure students are measuring the correct shadow dimension (length or width) stated in their question, and the shadow is being measured as described in the Preparation Section above. Have students record the measurement before moving onto the next trial. If your group has things under control, help other subgroups. As soon as subgroups finish their experiment, they can graph their results. Do not take down the experimental set-up until after students have finished their graph. This way they can check their measurements if needed. An example filled out results table is shown below (left).
Graph:
(10 minutes – Subgroups – SciTrek Volunteers)

Help students fill out their graph by having them complete the checklist on page 10. Be sure students label the y-axis with “Shadow Length (cm)” or “Shadow Width (cm),” and the x-axis with all of their changing variables. Students will need to decide what scale to use on the y-axis. Students can use ones, twos, or fives. Step 4 of the graphing checklist has students label their measurements in increasing order (1-4) on their results table to ensure that they are graphed in increasing order, as seen in the example above. This makes it easier for the students to see trends in their data. In the example above, the trials were graphed in the following order: B, D, A, C. Once students have graphed their values, make sure they write the numerical value of the shadow length or width on top of each column so that it is easy to quickly read the graph. An example filled out graph is shown above (right).

Note: It is okay if students do not complete their graph by the time the lead starts the Conclusion Activity. DO NOT have students go back and finish their graph (even if they only changed one variable). Students that do not finish their graph can present their second experiment and, therefore, will not need their first graph.

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

Note: Even if all students are not finished with their graphs, it is important to start the Conclusion Activity at least 10 minutes before the end of the session.

If students are still sitting on the floor, have them return to their original class seats. Have students turn to page 11 in their notebooks while you put the class notebook under the document camera and turn to
Tell students, “Before you analyze your graph and draw a conclusion, it is important that you recognize and understand other scientists’ conclusions.”

Ask the class, “What is a conclusion?” After listening to the students’ answers, make sure they understand that a conclusion is a claim supported by data. Write this definition on page 11 of the class notebook for the students to copy.

Tell students, “In order to make a conclusion, we need to make sure that we understand the difference between a claim and data.” First, read the definition of a claim and the example. Tell them, “A claim is a statement that we can verify by testing.” Have the class generate two examples of statements that are claims. After a student suggests a possible claim, ask the class, “Can this statement be verified by testing?” Have students hold their thumb up if it can, making it a claim, and down if it cannot. Several examples are shown below.

Examples:
- rabbits are faster than mice
- giraffes are taller than horses
- watermelons weigh more than pumpkins

Next, read the definition of data and the example. Note the example data supports the example claim, therefore, by combining the two statements, a conclusion can be formed. This conclusion would be: Donuts have more fat than toast, because 1 serving of donuts has 11 g of fat while 1 serving of toast has 5 grams of fat. Tell students, “Data often contains a numerical measurement such as a height (5 m) or a weight (20 kg). When you see data in a statement, you should box it.” Have students identify, and then box the data in the statement (11 g and 5 g). Ask students, “Does data have to contain a numerical measurement?” By the end of the conversation make sure students understand data can also be in the form of observations. Tell students, “When a statement contains observational data, the statement will say ‘we observed’ or ‘we recorded’ or something else to let you know the experiment was carried out.”

Ask students, “Do all statements have to be either a claim or data?” Lead students into realizing that some statements are neither a claim nor data. A common example of a statement that is not a claim or data is an opinion statement. Have students generate an example of an opinion statement.

Ex: Watermelons taste better than pumpkins.

Read the directions to part 2 aloud to the class. Tell students, “We will now work as a class to look for clues in the statements to identify whether it is a claim, data, or opinion, and then determine the type of statement.” For each statement, have a student share what they think the correct answer is and why. Have students vote using thumbs up/thumbs down if they agree/disagree with the student’s reasoning. After the class has come to a consensus, circle the correct answer on the class notebook for students to copy. If the statement is a claim, have the students state what data they would need to collect in order to make a conclusion. If the statement is data, have the students generate a claim that could be supported by that data.

For each statement box any information that is data, underline information that is a control, and double underline information that is an opinion.
Below are the explanations and answers to part 2 letters a-g on page 11.

**Letter a:** out of 10 people, only 3 can ride a unicycle

**Data (Data Collected: counted number of people)**

What type of statement is this, and how do you know?

Data, because it contains a measurement

What claim could be paired with this statement to make a conclusion?

More people are unable to ride a unicycle than those who are able

**Letter b:** puppies are cute

**Opinion**

What type of statement is this, and how do you know?

Opinion, because it contains the word cute

**Letter c:** people who get 4 hours of sleep experience dizziness

**Claim**

What type of statement is this, and how do you know?

Claim, because this is something that you can test

What data would you need to obtain to support the claim?

Count the number of people that feel dizzy after getting 4 hours of sleep and compare that to the number of people that do not feel dizzy

Are the numbers in this statement a measurement from the experiment?

No, the numbers are describing the experiment and are called descriptive numbers. Tell students that descriptive numbers are controls because they are values that are the same for all trials (write “descriptive number” above 4 hours).

**Letter d:** ants were observed on syrup, starbursts, and frosted flakes
Data (Data Collected: observed ants)
What type of statement is this, and how do you know?
Data, because it contains an observation
What claim could be paired with this statement to make a conclusion?
Ants are attracted to sugar

Letter e: the fastest land animal in the world is the cheetah
Claim
What type of statement is this, and how do you know?
Claim, because it can be tested
What data would you need to obtain to support the claim?
Find the time it takes different animals to run a set distance

Letter f: when 2 mL of vinegar was mixed with 2 g of baking soda, 1 L of gas was produced
Data (Data Collected: measured amount of gas produced)
What type of statement is this, and how do you know?
Data, because it contains a measurement
What claim could be paired with this statement to make a conclusion?
Mixing vinegar and baking soda results in a chemical reaction

Letter g: the more simple the flower, the more bees on the flower
Opinion
What type of statement is this, and how do you know?
Opinion, because it contains the word simple

If there is additional time, you can continue on to the next page of the Conclusion Activity. For details on how to do this see Day 4.

Wrap-Up:
(2 minutes – Full Class – SciTrek Lead)
Tell students, “Next session, you will analyze other scientists’ data to identify appropriate claims and data statements. You will then analyze your own data to see if you are able to draw a conclusion. Afterwards, you will get to design a second experiment.”

Clean-Up:
1. Collect notebooks with attached nametags.
2. Take ring stands apart.
3. Put ring stand poles, flashlight, clamps, ring stand bases, and clipboards back into their containers.
4. Place all other materials into your group box and bring them back to UCSB.
Day 4: Conclusion Activity/Conclusion/Question/Materials Page/Experimental Set-Up/Procedure

Schedule:
Introduction (SciTrek Lead) – 2 minutes
Conclusion Activity (SciTrek Lead) – 30 minutes
Conclusion (SciTrek Volunteers) – 5 minutes
Question (SciTrek Volunteers) – 5 minutes
Materials Page (SciTrek Volunteers) – 5 minutes
Experimental Set-Up (SciTrek Volunteers) – 5 minutes
Procedure (SciTrek Volunteers) – 6 minutes
Wrap-Up (SciTrek Lead) – 2 minutes

Materials:
(3) Volunteer Boxes:
- ☐ Student nametags
- ☐ Student notebooks
- ☐ Volunteer instructions
- ☐ Volunteer lab coat
- ☐ (3) Materials pages (subgroup color/number indicated)
- ☐ (2) Pencils
- ☐ (2) Red pens
- ☐ Notepad

Lead Box:
- ☐ (3) Extra student notebooks
- ☐ Lead instructions
- ☐ Shadows picture packet
- ☐ Lead lab coat
- ☐ (3) Materials pages
- ☐ Time card
- ☐ (2) Pencils
- ☐ (2) Red pens
- ☐ (2) Wet erase markers
- ☐ Notepad

Notebook Pages:

<table>
<thead>
<tr>
<th>SCIENTIFIC PRACTICES</th>
<th>Conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>3. Directions: Draw a line connecting claims with the correct data. If there is no data that supports the claim, do not draw a line.</td>
<td></td>
</tr>
</tbody>
</table>

- Claim 1. More people go to soccer matches than basketball games
  - Because 1 ml of diet coke weighs 5 g, and 1 ml of coke weighs 1.5 g.
  - Data 50% of people get heartburn when they use hot sauce and 20% of people get heartburn when they don’t use hot sauce.

- Claim 2. Spicy food causes heartburn
  - Data The air has been observed to be brown in areas with large numbers of cars.

- Claim 3. Cars increase air pollution
  - Data

- Claim 4. Diet coke weighs less than regular coke
  - Data 10 people went to the movies while 15 went shopping.

<table>
<thead>
<tr>
<th>SCIENTIFIC PRACTICES</th>
<th>Conclusions</th>
</tr>
</thead>
</table>

4. Each data table identifies the following statements as either Claim A, Claim B, or neither A nor B. Using the table, describe each statement and decide if it is correct or incorrect. State a claim or conclusion and follow the example below.

- a. the block affects whether the shadow length is a or b
  - Based on the data, the statement is incorrect.

- b. a larger block will result in a longer shadow
  - Correct Claim

- c. when a block is 5 cm tall, different shadows have different shadow lengths
  - Correct Claim

- d. when the light angle was the shadow length was a or b
  - Correct Claim

What data can be used to support claim b above? When the light angle was a or b, and when the light angle was c, the shadow length was d or e.
SCIENTIFIC PRACTICES

Conclusions

<table>
<thead>
<tr>
<th>Variables</th>
<th>Total A</th>
<th>Total B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light Angle</td>
<td>10 cm</td>
<td>15 cm</td>
</tr>
<tr>
<td>Shadow Length</td>
<td>5 cm</td>
<td>10 cm</td>
</tr>
<tr>
<td>Data</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total B</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5.

a. the longer the block the longer the shadow
   - Correct
   - Correct
   - Data
   - Incorrect

b. when the block height was 5 cm, the shadow length was 10 cm, and when the block height was 15 cm, the shadow length was 15 cm
   - Correct
   - Correct
   - Data
   - Incorrect

c. when the block height is smaller, the shadow length is longer
   - Correct
   - Correct
   - Data
   - Incorrect

d. the longer the block distance, the longer the shadow length
   - Correct
   - Correct
   - Data
   - Incorrect

If no claim can be made from the data state why not:

**No claim can be made because there is more than 1 changing variable.**

If no claim can be made from the results, can you make a conclusion?

[ ] Yes  [ ] No

Making a Conclusion from Your Data

How many changing variables did you have in your experiment?

2

Can you make a conclusion from your data?

[ ] Yes  [ ] No

**IF NO**

*Why I cannot make a conclusion because my experiment had more than 1 Changing Variable.*

**IF YES**

CONCLUSION

We can conclude:

[ ] Claim

because:

[ ] Data (measurement/observation)

Changing Variable(s) (Independent Variable(s))

For your second experiment, decide which variable(s) (max three) that you would like to test.

Changing Variable 1: block length

Changing Variable 2 (optional):

Changing Variable 3 (optional):

What will you measure? (Circle one):

[ ] Shadow Length
[ ] Shadow Width

**QUESTION**

Question our subgroup will investigate:

- If we change the ______ block length ______, what will happen to the ______ shadow length ______?

[ ] What you are measuring (independent variable)

SciTrek Member Approval: LD

Get a materials page from your SciTrek volunteer and fill it out before moving onto the experimental set-up.
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 Conclusion Activity (pages 12-15, 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. Pass out notebooks/nametags.
2. Make sure you have three materials pages, each filled out with a subgroup number (1, 2, or 3) and your group’s color to give to subgroups after they complete their question.
3. Have a red pen available to approve subgroups’ questions, experimental set-ups, and procedures (pages 17, 18, and 19).

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

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

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

Tell students, “Today you are going to match claims with appropriate data and then analyze scientists’ data to determine which claims and data are appropriate for a given set of results. Afterwards, you will analyze your own data to see if you can make a claim/conclusion. You will then have the opportunity to
design a second experiment or redesign your first experiment, which will be carried out during the next visit.”

**Conclusion Activity:**
*(30 minutes – Full Class – SciTrek Lead)*

Have students turn to page 12 in their notebooks. Place the class notebook under the document camera and open to page 12.

Ask students, “What is the definition of a conclusion?” Students should reply, “A claim supported by data.” Ask students, “What is the definition of a claim?” Students should reply, “A statement that can be tested.” Ask students, “What type of information can be used for data?” Students should reply, “Measurements or observations.”

Tell students, “You are now going to try matching claims with supporting data. Be sure to read the statements carefully, because not all of the claims will make a match. Only draw lines between the claims that match up with supporting data.” Allow students approximately 2 minutes to work by themselves, and then go over the answers as a class.

Ask the class, “Has anyone identified a match?” Then, have them give you the number and the letter of the possible match. Read each suggested claim/data match and then have the rest of the class show whether they agree/disagree using thumbs up/thumbs down. If they disagree, ask a student to explain. Continue asking students if they are able to make any other connections until all possible matches are made.

<table>
<thead>
<tr>
<th>Claim</th>
<th>Because</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. More people go to soccer matches than basketball games</td>
<td>1 ml of diet coke weighs 5 g, and 1 ml of coke weighs 1 g.</td>
<td>a. 1 ml of diet coke weighs 5 g, and 1 ml of coke weighs 1 g.</td>
</tr>
<tr>
<td>2. Spicy food causes heartburn</td>
<td>5/8 of people get heartburn when they use hot sauce and 3/8 of people get heartburn when they don’t use hot sauce.</td>
<td>b. 5/8 of people get heartburn when they use hot sauce and 3/8 of people get heartburn when they don’t use hot sauce.</td>
</tr>
<tr>
<td>3. Cars increase air pollution</td>
<td>The air has been observed to be brown in areas with large numbers of cars.</td>
<td>c. The air has been observed to be brown in areas with large numbers of cars.</td>
</tr>
<tr>
<td>4. Diet coke weighs less than regular coke</td>
<td>10 people went to the movies while 15 went shopping.</td>
<td>d. 10 people went to the movies while 15 went shopping.</td>
</tr>
</tbody>
</table>
Below are correct matches that can be made from this activity.

1. Spicy food causes heartburn, because 50% of people get heartburn when they use hot sauce and 10% of people get heartburn when they don’t use hot sauce.
   This is a correct match because the data clearly supports the claim using numerical values as data to make a conclusion.

2. Cars increase air pollution, because the air has been observed to be brown in areas with large numbers of cars.
   This is a correct match because the data clearly supports the claim using an observation to make a conclusion.

Below are incorrect matches that can be made from this activity.

3. Diet coke weighs less than regular coke, because 1 mL of diet coke weighs 5 g and 1 mL of coke weighs 1.1 g.
   This is an incorrect match because the data does not support the claim. The claim says that diet coke weighs less than regular coke, however, the data supports the opposite claim that diet coke weighs more. Ask students, “In order to make a conclusion, do you think scientists can change the claim or the data?” Students should realize that scientists can change their claims, but they cannot change their data. In addition, scientists must include all data when generating a claim.

4. More people go to soccer matches than basketball games, because 10 people went to the movies, while 15 went shopping.
   This is an incorrect match because the data has nothing to do with and does not support the claim. Therefore, this is an incorrect conclusion.

Once this page is complete have the students turn to page 13 in their notebooks.

Have students annotate the results table. As a group, identify and then underline the controls (light color, block height, block width, light distance, and light height), circle the changing variable (light angle), and box the information about the data collected (shadow length).

Tell students, “We are now going to look over a list of statements about this results table and decide whether each statement is an example of a claim or data. If the statement is a claim, we will identify and circle the changing variable, if the statement is data, we will box the data. We will then use the results table to tell if the statement is a correct claim, correct data, or incorrect.”

First, read the statement and have students classify the statement as claim or data and write the corresponding letter, C or D, on the line. Second, have students help you annotate the statement by circling the changing variable (every claim statement will have a changing variable), underlining controls, and boxing any data. Third, have students check the results table to see if the statement is a correct claim, correct data, or incorrect and circle the appropriate answer. Repeat this process for each statement.

If students are struggling to identify the changing variable, ask them, “What experiment would we need to carry out to test this claim?” From their answer, have them identify what they changed.
**Letter a:** the light height affects the length of the shadow
*Claim/Incorrect (Variable Held Constant)*

What type of statement is this, and how do you know?
Claim, because it can be tested (write C on the line)

What would need to be the changing variable for this claim to be correct?
Light height (circle light height)

Is light height a changing variable in this experiment?
No

What should we circle?
Incorrect

**Letter b:** a larger light angle will result in a longer shadow
*Claim/Correct Claim*

What type of statement is this, and how do you know?
Claim, because it can be tested (write C on the line)

What would need to be the changing variable for this claim to be correct?
Light angle (circle light angle)

Is light angle a changing variable in this experiment?
Yes

Is the claim consistent with the data?
Yes

What should we circle?
Correct claim

**Letter c:** when a block is 9 cm tall, different light angles give different shadow lengths
*Claim/Correct Claim*

What type of statement is this, and how do you know?
Claim, because it can be tested (write C on the line)

What would need to be the changing variable for this claim to be correct?
Light angle (circle light angle)

Is the 9 cm data?
No, it is a descriptive number (one of the controls) (underline 9 cm)

Is light angle a changing variable in this experiment?
Yes

Is the claim consistent with the data?
Yes

What should we circle?
Correct claim

**Letter d:** when the light angle was 60° the shadow length was 6 cm
*Data/Incorrect*

What type of statement is this, and how do you know?
Data, because it contains a measurement (write D on the line and box 6 cm)

What is the 60°?
This is a value of the changing variable (circle 60°)

Is the data correct based on the results table?
No

What should we circle?
Incorrect
Tell students, “We are now going to determine the data to support claim b.” Read claim b aloud (a larger light angle will result in a longer shadow) and ask students, “What data can be used to support this claim?” Possible student response: when the light angle was 30° the shadow length was 6 cm and when the light angle was 60° the shadow length was 10 cm. Record this statement in the class notebook. Ask students, “How would people know that the statement generated was data?” Possible student response: the statement contains measurements. In the statement, box the measurements “6 cm” and “10 cm” and circle the changing variable values “30°” and “60°.” Then, read the complete conclusion: a larger light angle will result in a longer shadow because when the light angle was 30° the shadow length was 6 cm and when the light angle was 60° the shadow length was 10 cm.

Ask students, “Can multiple claims be made about a given set of results?” Possible student response: both b and c were correct claims therefore, multiple claims can be made from the same data. Ask students, “Which claim do you think gives the most information, or tries to explain why the shadow is changing lengths?” Students should realize that the claim (claim b), a larger light angle will result in a longer shadow, gives the most information because it states how the shadow might be getting longer. Tell them, “This type of claim also allows scientists to make predictions about systems that have not been experimented with yet. I encourage you all to think about how and why your shadows are changing lengths when you make a claim from your own data.”

Have students turn to page 14 in their notebooks. Turn the example notebook to page 14.

Have students annotate the results table. As a group, identify and then underline the controls (light color, block width, light height, and block angle), circle the changing variables (block height and light distance), and box the information about the data collected (shadow length).

Tell students, “We are now going to go through the same process that we went through for the statements about the last results table.”
Letter a: the brighter the light, the longer the shadow
Claim/Incorrect (No Data Gathered)
What type of statement is this, and how do you know?
Claim, because it can be tested (write C on the line)
What would need to be the changing variable for this claim to be correct?
Light brightness (circle brighter the light)
Is light brightness a changing variable in this experiment?
No
What should we circle?
Incorrect

Letter b: when the block height was 6 cm, the shadow length was 5 cm, and when the block height was 10 cm, the shadow length was 13 cm
Data/Correct Data
What type of statement is this, and how do you know?
Data, because it contains measurements (write D on the line and box 5 cm and 13 cm)
What are 6 cm and 10 cm?
6 cm and 10 cm are both changing variables (circle 6 cm and 10 cm)
Is the data correct based on the data table?
Yes
What should we circle?
Correct data

Letter c: when the block height is smaller, the shadow length is longer
Claim/Incorrect (Inconsistent with Data)
What type of statement is this, and how do you know?
Claim, because it can be tested (write C on the line)
What would need to be the changing variable for this claim to be correct?
Block height (circle block height)
Is block height a changing variable in this experiment?
Yes
Is the claim consistent with the data?
No
What should we circle?
Incorrect

Letter d: the longer the light distance, the longer the shadow length
Claim/Incorrect (More than One Changing Variable)
What type of statement is this, and how do you know?
Claim, because it can be tested (write C on the line)
What would need to be the changing variable for this claim to be correct?
Light distance (circle light distance)
Is light distance a changing variable in this experiment?
Yes
Is the claim consistent with the data?
Yes
Is this claim fair or could the shadow length be changing because of another reason?
This claim is not fair because the shadow length could have changed as a result of changing the block height
What should we circle?
Incorrect
Ask students, “Why can’t a claim be made from the data?” Possible student response: there is more than one changing variable and you cannot tell which variable affected the results or how/why these changing variables affected the shadow length. Record this answer on the class notebook and have students copy this into their notebooks.

Ask students, “Do you think a conclusion can be made from the data if a claim cannot be made?” Possible student response: since a conclusion is defined as a claim supported by data, you would need both a claim and data to make a conclusion. Since no claims can be made, a conclusion cannot be made either. Have students check the “no” box in their notebook.

Ask students, “What did you learn about conclusions from this activity?” Make sure by the end of the conversation that students understand that in order to draw a conclusion, they must only have one changing variable.

Tell students, “You are now going to look at three results tables and one graph and determine which data sets would allow you to make a claim/conclusion.” As a class, go through each table/graph and underline the controls, circle the changing variable(s), and box information about data collection. Then have students decide if that group could make a claim/conclusion before moving to the next table/graph.
Ask students the following questions:

**Table A**

- How many changing variables are there?
  - Three
- What is/are the changing variable(s)?
  - Block height, light distance, and light angle
- Can a claim/conclusion be made from this data?
  - No
- Why not?
  - This experiment had three changing variables, and conclusions/claims can only be made when there is one changing variable.

**Table B**

- How many changing variables are there?
  - One
- What is/are the changing variable(s)?
  - Light height
- Can a claim/conclusion be made from this data?
  - Yes
- Did the light height affect the length of the shadow?
  - Yes
Table C
How many changing variables are there?
One
What is/are the changing variable(s)?
Block height
Can a claim/conclusion be made from this data?
Yes
Did the block height affect the length of the shadow?
Yes

Graph D
How many changing variables are there?
Two
What is/are the changing variable(s)?
Block width and light height
Can a claim/conclusion be made from this data?
No
Why not?
This experiment had two changing variables, and conclusions/claims can only be made when there is one changing variable.

Tell students, “Tables (such as tables A-C) and graphs (such as graph D) represent two different ways of displaying results from an experiment.” Ask students, “What are the advantages and disadvantages of tables versus graphs?” Students should realize that viewing the data in table form yields a complete idea about what experiment was conducted and which controls were used. However, it is harder to see patterns in the data. Alternatively, viewing the data in graph form allows patterns and trends to be viewed but does not display the controls the experimenter used.

Tell students, “You will now analyze your own data to see whether you can make a conclusion. Remember, it is okay if you cannot draw a conclusion from your first experiment, because you will have the opportunity to run another experiment. When you run a second experiment, you should only change one variable, so that you will be able to draw a conclusion. Once you have decided whether you can or cannot make a conclusion, you will either use your results to make a conclusion, or state why you cannot make a conclusion from your data. After, you can move on to designing your new experiment. You are going to give poster presentations at the end of the module and the presentations will be more interesting if there are a wide range of changing variables that have been tested. In addition, if a wide range of variables are chosen, the class question (What variables affect shadows?) will be more completely answered. Therefore, I challenge you to try to explore a changing variable that you think no one else in the class is investigating.”

Tell students, “You will start working with your subgroup to analyze your old experiment and start your new experiment.”
Conclusion:
(5 minutes – Subgroups – SciTrek Volunteers)

Help subgroups fill out page 16 of their notebooks. If the subgroup has more than one changing variable, they will not be able to draw a conclusion. An example of a scenario in which students cannot make a conclusion is shown below (left).

If the subgroup has only one changing variable, they will be able to make a conclusion. Make sure that the students’ conclusions have both a claim (a statement that can be tested) and supporting data (measurements and/or observations) and that these statements are in the appropriately labeled sections. Conclusions are still valid, and important, if they show that the changing variable tested did not affect the shadow. Even if their conclusion is contrary to what you think, have students make a claim based solely on their data. If you think that their data is flawed it is okay to ask them what they think went wrong and encourage them to repeat their experiment. An example of a scenario in which students can make a conclusion is shown below (right).

Question:
(5 minutes – Subgroups – SciTrek Volunteers)

Have subgroups decide what changing variable they want to explore for their second experiment. Make sure each subgroup has only one changing variable so that they will be able to make a claim/conclusion after 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.
After subgroups have decided on their changing variable, have them decide and circle what they will measure. They can then 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 (E, F, G, H) next to the value they select. Ask students, “Why did you choose the values you did for your controls and changing variable, and will these values make it easier or harder to answer your question?”

Make sure students have picked light distances and light heights that are within the limitations given on the materials page. In addition, ensure that students have no more than one block dimension changing. An example filled out materials page is shown below.
Experimental Set-Up:
(5 minutes – Subgroups – SciTrek Volunteers)

Have subgroups use the materials page to fill in their experimental set-ups on page 18 of their notebooks. 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 start their experiments on Day 5. An example filled out experimental set-up is shown below.
**Procedure:**

(6 minutes – Subgroups – SciTrek Volunteers)

After each subgroup has filled out their experimental set-up, they can start on their procedure (page 19, student notebook). Make sure that students within the same subgroup are collaborating to write the procedure. Keep procedures as brief as possible while still conveying the pertinent information about the experiment (control values, changing variable values, and what data they will collect). An example step for a subgroup that had block height as a changing variable would be, “Place block that is 7 cm wide, 3 cm long, and E) 2 cm, F) 5 cm, G) 8 cm, and H) 10 cm tall on the white plastic.” Some subgroups may struggle with writing a procedure. If they are struggling, tell them to look back at their initial procedure on page 8 of their notebooks. If they are still having trouble, you can have these subgroups dictate each step while you transcribe them onto a notepad found in your group box. Give this sheet to the students to copy into their notebooks. Students might not finish their procedure this day. There will be additional time for them to finish their procedure on Day 5. If students do finish their procedure, they should raise their hand and get their procedure approved by their volunteer. An example filled out procedure can be seen below.
**Wrap-Up:**

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

Tell students, “Next session, you will carry out the experiments that you designed today.”

**Clean-Up:**

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

**Day 5: Procedure/Results Table/Experiment/Graph/Conclusion**

**Schedule:**

- Introduction (SciTrek Lead) – 10 minutes
- Procedure (SciTrek Volunteers) – 5 minutes
- Results Table (SciTrek Volunteers) – 5 minutes
- Experiment (SciTrek Volunteers) – 25 minutes
- Graph (SciTrek Volunteers) – 5 minutes
- Conclusion (SciTrek Volunteers) – 8 minutes
- Wrap-Up (SciTrek Lead) – 2 minutes
Materials:
(3) Volunteer Boxes:
☐ Student nametags
☐ Student notebooks
☐ Volunteer instructions
☐ Picture of Experimental Set-up
☐ Volunteer lab coat
☐ (2) Pencils
(3) Ziploc bags with the following: (labeled with subgroup number)
☐ Measuring tape (152 cm)
☐ Requested block(s)
☐ (3) Rulers
☐ Protractor
☐ (2) Red pens
☐ Masking tape
☐ Notepad
☐ (3) White plastic surfaces
☐ Filled out materials page

Other Supplies:
☐ Box with 9 ring stand bases, 9 flashlights, and 9 clamps with string attached
☐ Tube with 9 ring stand poles
☐ (35) Clipboards

Lead Box:
☐ (3) Extra student notebooks
☐ Lead instructions
☐ Shadows picture packet
☐ Picture of Experimental Set-up
☐ Lead lab coat
☐ Time card
☐ (2) Pencils
☐ (2) Red pens
☐ (2) Wet erase markers
☐ Notepad
☐ (6) Rulers
☐ (2) Masking tapes
☐ (2) Filled out materials page
☐ Bag of lead shadows supplies:
☐ (3) measuring tapes (152 cm), (2) flashlights without filter, (4) AAA batteries, (2) protractors, (2) clamps with string attached, (9) blocks – one of each size
☐ White plastic surface

Notebook Pages:

<table>
<thead>
<tr>
<th>Variables</th>
<th>Trial A</th>
<th>Trial B</th>
<th>Trial C</th>
<th>Trial D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light Color:</td>
<td>White</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Block Height:</td>
<td>7 cm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Block Widths:</td>
<td>3 cm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Block Lengths:</td>
<td>5 cm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Light Intensity:</td>
<td>100 cm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Light Angle:</td>
<td>0°</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Write a conclusion from the results above:

We can conclude that for a given block dimension, the shadow length will be the same regardless of the block material, because the blocks made from wood, foam, metal, and cardboard all had shadow lengths of 12 cm.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Trial E</th>
<th>Trial F</th>
<th>Trial G</th>
<th>Trial H</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light Color:</td>
<td>White</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Block Height:</td>
<td>7 cm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Block Widths:</td>
<td>3 cm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Block Lengths:</td>
<td>3 cm</td>
<td>10 cm</td>
<td>8 cm</td>
<td>6 cm</td>
</tr>
<tr>
<td>Light Intensity:</td>
<td>50 cm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Light Angle:</td>
<td>60°</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The independent variable(s) is (are) the changing variable(s) and the dependent variable is the final measurement/observation.
**Preparation:**

**SciTrek Lead:**

1. Make sure volunteers are passing out notebooks.
2. Make sure volunteers are setting up for the experiment.
3. If the classroom has a document camera, ask the teacher to use it for the conclusion example (page 20, student notebook) and the block measurement picture (page 1, picture packet). If the classroom does not have a document camera, then tape the poster-size notebook pages to the front board.
4. Have example block available to show students during the introduction.

**SciTrek Volunteers:**

1. Pass out notebooks/nametags.
2. Set-up experiments in separate areas on the floor.
   a. Put the ring stands together and attach the flashlight to the clamp. Make sure the flashlight is flush with the front of the clamp. Place the clamp at the lowest place on the ring stand to allow students to put the clamp at the appropriate height(s) when they do their experiment.
   b. Place bags with supplies (labeled with subgroup number), white plastics, and ring stand/clamp set-ups in three unique spots on the floor along with four clipboards.
3. Have a red pen available to approve student’s procedure (page 19).

**Note:** Pass out notebooks to students. If needed, students will move to their subgroups after the Introduction.
How to Measure Lengths and Widths of Shadows

When measuring the length of the shadow, line up the 0 cm mark of a ruler with the front of the block (front of the white plastic). If your shadow length is longer than 30 cm, you will need to use the measuring tape instead of the ruler. The lead box has extra measuring tapes, if needed. Place another ruler (numbers side down) perpendicular to the first ruler at the edge of the shadow making an “L” with the two rulers. The shadow length can be read from the ruler which has its numbers exposed. The shadow length in the picture below on the left is 7 cm.

When measuring the width of the shadow, place two rulers (numbers side down) perpendicular to the short side of the white plastic on either side of the shadow. Measure the shadow width by placing a third ruler perpendicular to the two rulers, resulting in the rulers making an “H.” The shadow width in the picture below on the right is 8 cm.

Introduction:

(10 minutes – Full Class – SciTrek Lead)

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

Ask the class, “What is the class question that we have been investigating?” Students should reply, “What variables affect shadows? Tell students, “Today you are going to perform your second experiment. Once the experiment is complete, you will analyze your data and determine what conclusions can be drawn from your results. Your conclusions will help answer the class question.” Ask students, “What is the definition of a conclusion?” Students should reply, “A claim supported by data.” Ask students, “How many changing variables can experiments have in order to make claims/conclusions?” Students should reply, “One changing variable.” Ask them, “Why can we only have one changing variable in order to draw a conclusion?” Possible student response: if there is more than one changing variable, we would not be able to tell which one of the multiple changing variables affects the shadow.

Tell students, “To help learn how to analyze data, we will look at other scientists’ data to see if we can draw a conclusion from their results.” Have students turn to page 20 of their notebook and place the class notebook under the document camera. Tell students, “Look over the data in this results table.” Ask students, “What was the changing variable in the experiment?” Students should reply, “Block material.” Have students circle block material. Next, have students identify and underline the controls for the
experiment. Students should underline light color, block height, block width, block length, light distance, light height, and light angle. Lastly, have students identify the data the scientists collected and box that information. Students should box shadow length. Ask students, “What was the question these scientists were exploring?” Students should reply, “If we change the block material, what will happen to the shadow length?” Fill in the changing variable in the blank in the question above the results table. Ask students, “Can a claim/conclusion be made from this data?” Students should realize there is only one changing variable, so a claim/conclusion can be made from these results.

Tell the class, “Now that you know a conclusion can be made from the data, you are going to work together to come up with a conclusion. When drawing a conclusion from data, the first step is making a claim to explain the results.”

Then ask, “Can anyone look at the data and tell me how the block material affected the shadow length?” Possible student response: since all of the shadow lengths are the same, the block material does not affect the shadow.

Example claim that states how the shadow is affected by the block material:

1. for a given light source and a given block dimension, the shadow length will be the same regardless of the material the block is made from

Example claim that states what happened:

1. the block material does not affect the length of the shadow

If possible, try to lead the students to a claim that explains how the shadow changed instead of a claim that just states what happened to the shadow. Tell students, “Claims that allow you to make predictions are more valuable in science because we can then go out and further test our claims to see if they are correct. Therefore, when you try to generate a claim about your data, you should try to have a claim that would allow you to make a prediction.” Write the claim in the class notebook and have students copy it into theirs.

Ask students, “What data was collected to support this claim?” Below is an example of data that supports claims that stated how the shadow was affected.

1. the blocks made out of wood, foam, metal, and cardboard all had a shadow length of 12 cm.

Ask students, “How do you know that the statement generated was data?” Possible student response: the statement contains measurements, showing that scientists had to go and physically carry out an experiment to discover the results. Write the data after the claim in the class notebook and have students copy it into their notebooks. Make sure students understand that the conclusion they made is the outcome of their experiment and should answer the experimental question. In addition, these smaller experimental questions can be combined to help answer a larger question, such as the class question.
Remind students how we define the block dimensions. Show students the example block. Place the block on the edge of the picture packet and tell them “The picture packet will represent the white plastic and the light source would be in front of the block.” Ask students, “What do we call the block dimension going up?” Students should reply, “Height.” Ask students, “What do we call the block dimension going across the front of the white plastic?” Students should reply, “Width.” Ask students, “What do we call the block dimension going away from the light?” Students should reply, “Length.” Show students they can look at the picture at the top of their results table if they forget which dimension is which.

Put page 1 of the picture packet under the document camera and review how to measure the length and width of the shadow. Have students identify, by raising their hands, if they are measuring shadow length. Then, tell those students, “When measuring the length of the shadow, you will line up the 0 cm mark of a ruler with the front of the block (front of the white plastic). You will then place another ruler (numbers side down) perpendicular to the first ruler at the edge of the shadow, making an ‘L’ with the two rulers.” Have students identify by raising their hands if they are measuring shadow width. Then, tell those students, “When measuring the shadow width, you will place two rulers (numbers side down) perpendicular to the short side of the white plastic on either side of the shadow. You will then measure between the two rulers with a third ruler to find the shadow width resulting in the rulers making an ‘H’ with the three rulers.”

Remind students they must have their procedure and results table completed before they can start their experiment.

**Procedure:**

(5 minutes – Subgroups – SciTrek Volunteers)

Help subgroups complete their procedures (page 19, student notebook). Make sure that students within the same subgroup are collaborating to write the procedure. Keep procedures as brief as possible while...
still conveying the pertinent information about the experiment (control values, changing variable values, and what data they will collect). An example step for a subgroup that had block height as a changing variable would be, “Place block that is 7 cm wide, 3 cm long, and E) 2 cm, F) 5 cm, G) 8 cm, and H) 10 cm tall on the white plastic.” Some subgroups may struggle with writing a procedure. If they are struggling, tell them to look back at their initial procedure on page 8 of their notebooks. If they are still having trouble, you can have these subgroups dictate each step while you transcribe them onto a notepad found in your group box. Give this sheet to the students to copy into their notebooks. Once students finish, they should raise their hands and get their procedure approved by their volunteer. An example filled out procedure can be seen below (left).

![Procedure Example](image)

**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 E box and then draw an arrow through the remaining trials’ boxes. For the changing variable, they should write the values in each trial’s corresponding box.

When students have finished, have them make predictions about the shadows. Have them write “B” in the box of the trial they think will produce the biggest shadow length/width and “S” in the box of the trial they think will produce the smallest shadow length/width. They will leave two of the boxes empty. If they think all trials will produce the same shadow length/width, have them write “same” over all of the boxes. It is okay if the students in a subgroup have different predictions. An example filled out results table can be seen above (right).
Experiment:  
(25 minutes – Subgroups – SciTrek Volunteers)

Once subgroups have finished their results tables, show them where their supplies are. If students are missing any of their experimental materials, the lead box has extra materials. If students have a fixed light angle, you can give them masking tape from your group box to tape down their measuring tape so it does not move. For these students, the measuring tape should go under the protractor. For subgroups changing light angle, have the protractor’s swing arm in the correct orientation and then put the measuring tape on top of the protractor. Do not tape down the measuring tape because it will be moved for the next trial. Remind students to make sure that the flashlight is in line with the protractor, and the string is hanging down from the front of the clamp.

Have students show you their set-up for their first trial before taking any measurements. When checking students’ set-up, verify they have their block in the correct orientation. If students chose to change the light angle and the shadow becomes too wide for the white plastic, the plastic may be moved to see the entire shadow. However, make sure that the direction the block faces does not change when the white plastic is moved. If the shadow is longer or wider than the ruler, have students use a measuring tape found in the lead box.

Make sure students are measuring the correct shadow dimension (length or width) stated in their question and the shadow is being measured as described in the Preparation Section above. Have students record the measurement before moving onto the next trial. If your group has things under control, help other subgroups. As soon as subgroups finish their experiments, they can graph their results. Do not take down the experimental set-up until after students have finished their graph. This way they can check their measurements if needed. An example filled out result table is shown in the Graph Section, below (left).

Graph:  
(5 minutes – Subgroups – SciTrek Volunteers)

Help students fill out their graph by having them complete the checklist on page 22. Be sure students label the y-axis with “Shadow Length (cm)” or “Shadow Width (cm),” and the x-axis with their changing variable. Students will need to decide what scale to use on the y-axis. Students can use ones, twos, or fives. Step 4 of the graphing checklist has students label their measurements in increasing order (1-4) on their results table to ensure that they are graphed in increasing order, as seen in the example below. This makes it easier for the students to see trends in their data. In the example below, the trials were graphed in the following order: E, H, G, F. Once students have graphed their values, make sure they write the numerical value of the shadow length or width on top of each column so that it is easy to quickly read the graph. An example filled out graph is shown below (right).
Conclusion:
(8 minutes – Subgroups – SciTrek Volunteers)

Have students use their graph to look for a pattern in their data. Challenge students to think about how their changing variable did or did not affect the shadows’ length/width.

When writing their conclusion (page 23, 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 the values of their changing variable have an order (Ex: 2 cm → 5 cm → 8 cm → 10 cm), then, that variable affects the shadow length/width. If, on the other hand, there was no order for their changing variable values (Ex: 5 cm → 10 cm → 2 cm → 8 cm) and the difference between shadow lengths/widths for each trial is small, then that variable did not affect the shadow length/width. If possible, try to have students generate a claim that allows them to make predictions about something that they have not tested. Challenge students to think about how (claim 1 and 2 below) their changing variable did or did not affect their measurements instead of just what happened (claim 3 below).

Example claims that state how the changing variable did or did not affect the shadow.

Claim 1: the taller the block, the longer the shadow
Claim 2: as the light height increases, the shadow becomes more rectangular and less trapezoidal

Example claims that state what happened to the shadow.

Claim 3: the block height affects the shadow length

Once they have discussed their ideas, have the students fill out the section labeled: “Generate a claim about how your changing variable affected your results” (page 23, student notebook).
If there is time, students can determine the data to support their claim. For an example of how to do this, see the Conclusion section on Day 6. Example student work for the conclusion section can be seen below.

**CONCLUSION**

We can conclude that the block length will slightly increase the shadow length when the light distance and light height are both 50 cm because when the block length was 3 cm, the shadow length was 7 cm and when the block length was 10 cm, the shadow length.

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**Wrap-Up:**

*(2 minutes – Subgroups – SciTrek Lead)*

Tell students, “Next session, you will have time to finish your conclusions and then make a poster to share your results with the class.”

**Clean-Up:**

1. Collect notebooks with attached nametags.
2. Take ring stand apart.
3. Put ring stand poles, flashlights, clamps, ring stand bases, and clipboards back into their containers.
4. Place all other materials into your group box and bring materials back to UCSB.

**Day 6: Conclusion/Poster Making**

**Schedule:**

- Introduction (SciTrek Lead) – 2 minutes
- Conclusion (SciTrek Volunteers) – 18 minutes
- Poster Making (SciTrek Volunteers) – 35 minutes
- Wrap-Up (SciTrek Lead) – 5 minutes
Materials:

(3) Volunteer Boxes:
- ☐ Student nametags
- ☐ Student notebooks
- ☐ Volunteer instructions
- ☐ Volunteer lab coat
- ☐ Poster diagram
- ☐ (3) Stickers on how to present graph
- ☐ (2) Pencils
- ☐ Notepad
- ☐ (9) Paperclips
- ☐ Highlighter
- ☐ Scissors
- ☐ (2) Glues

☐ (3) Poster parts packs (scientists’ names, question, experimental set-up, procedure, results table, results graph, conclusion, (4) “I acted like a scientist when”, (4) picture spaces)

Other Supplies:
- ☐ Poster paper tube

Lead Box:
- ☐ (3) Extra student notebooks
- ☐ Lead instructions
- ☐ Shadows picture packet
- ☐ Lead lab coat
- ☐ Poster diagram
- ☐ Time card
- ☐ (3) Stickers on how to present graph
- ☐ (2) Pencils
- ☐ (2) Wet erase markers
- ☐ Notepad
- ☐ (9) Paperclips
- ☐ (2) Highlighters
- ☐ (2) Scissors
- ☐ (2) Glues
- ☐ Scotch tape
- ☐ (3 each color) Poster part packs

Preparation:

SciTrek Lead:
1. Make sure volunteers are setting out notebooks.
2. Ask the classroom teacher for a place to leave student posters.

SciTrek Volunteers:
1. Set out notebooks/nametags.

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:

(2 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.”

Ask the class, “What is the class question we have been investigating?” Students should reply, “What variables affect shadows?” Tell students, “Today you are going to finish your conclusions and make posters to present your findings to the class.” Ask students, “How do scientists define a conclusion?” Students should reply, “A claim supported by data.” Ask students, “What is a claim?” Students should reply, “A statement that can be tested.” Ask students, “What can be used for data?” Students should reply, “Measurements or observations.”

Tell students, “After you finish your conclusion, 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. You will get to pick which one of your two experiments to present, but it should be an experiment in which you were able to draw a conclusion. 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.”
If students have not made a claim about their data, have them analyze the data in their graph in order to make one. For an example of how this is done, see the Conclusion section in Day 5.

After generating a claim about their experiment, students will put the supporting data after the “because.” Their supporting data should include at least two pieces of data, typically the minimum and maximum lengths/heights. Make sure students are using their changing variable values (not trial letters) and specific measurements to support their claim.

Example data to support the three claims that were previously listed.

Data 1: the shadow length for the 10 cm (tallest) block was 15 cm and the shadow length for the 3 cm (shortest) block was 4.5 cm
Data 2: it was observed that when the light height was 10 cm the shadow was a trapezoid and when the light height was 60 cm the shadow was a rectangle
Data 3: the shadow length for the 10 cm block was 15 cm and the shadow length for the 3 cm block was 4.5 cm

Conclusions are still valid, and important, if they show that the changing variable tested did not affect the shadow length/height. Even if their conclusion is contrary to what you think, have students make a claim based solely on their data.

Once students have determined their conclusion, have them complete the two questions that follow. First, have them verify that the first part of their statement is testable, making it a claim. If it is not a claim, have them go back and revise the first part of the statement. Second, have students justify how they know the second part of the statement is data. Statements that are data contain measurements or observations. If the statement is an observation, make sure the word “recorded” or “observed” is in the statement to indicate that the experiment was carried out. If the data statement does not have a measurement or an observation, have students modify their statement.

An example filled out conclusion is shown below.
Before starting their poster, have students fill in the sentence frame (page 23, 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:**
*(35 minutes – Subgroups – SciTrek Volunteers)*

Each subgroup (three/four students) will make one poster about one of their experiments from which they were able to draw a conclusion. If a subgroup was able to make a conclusion from both experiments, they can choose whichever experiment they think will better help answer the class question.

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>
<th>Poster Division</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>1. Question and Experimental Set-Up</td>
<td>Student that finishes 1st completes the results table <em>(not presented)</em></td>
</tr>
<tr>
<td></td>
<td>2. Procedure</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Results Graph* and Conclusion</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>1. Question and Experimental Set-Up</td>
<td>Student that finishes 1st completes the results table <em>(not presented)</em></td>
</tr>
<tr>
<td></td>
<td>2. Procedure</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Results Graph*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Conclusion</td>
<td></td>
</tr>
</tbody>
</table>

*Give the results graph 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 graph, and 6) conclusion (see example below). Students will NOT present the results table or “I acted like a scientist when” parts 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 the following sentence frame sticker on the notebook page of the student who is presenting the results graph (page 22, student notebook).

When the _______________ was _____________ the shadow _______________ was _______________.

Then, practice reading the four sentences with that student. For the graph above, the first sentence would read: When the block length was 3 cm the shadow length was 7 cm. Make sure you fill in the first and third blanks in the sentence frame (Ex: block length and length) for the student, but leave the “value” and “measurement” blanks empty.
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 shadow for other changing variable values that they did not test. For instance, if the subgroup’s conclusion was, “The shorter the light height the longer the shadow, because when the light height was 25 cm the shadow length was 40 cm and when the light height was 45 cm the shadow length was 20 cm,” ask the subgroup to predict what the shadow length will be for 35 cm. They should be able to predict that it would be ~35 cm.

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 them back to UCSB.

Day 7: Poster Presentations

Schedule:

Introduction (SciTrek Lead) – 2 minutes
Practice Posters (SciTrek Volunteers) – 5 minutes
Poster Presentations (SciTrek Volunteers/SciTrek Lead) – 51 minutes
Wrap-Up (SciTrek Lead) – 2 minutes

Materials:

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

Lead Box:
- ☐ (3) Extra student notebooks
- ☐ Lead instructions
- ☐ Shadows picture packet
- ☐ Lead lab coat
- ☐ Time card
- ☐ (3) Stickers on how to present graph
- ☐ (2) Pencils
- ☐ (9) Paperclips
- ☐ (2) Highlighters
- ☐ Scotch tape

*Student posters should already be in the classroom.

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 4 and 5, picture packet). If the classroom does not have a document camera, then write the class question on the board, “What variables affect shadows?” 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: block height, block width, block length, light height, light distance, light angle).

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

Note: Today students will sit in their regular classroom seats during poster presentations.
Picture Packet Pages: (Student notebook pages 24 and 25 are almost identical to picture packet pages 4 and 5, but have one less subgroup space.)

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 5 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:
(5 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: block height, block width, block length, light height, light distance, light angel).

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 graph, and conclusion). 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.

Do not let poster practice go over 5 minutes.

**Poster Presentations:**
*(51 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 shadows?” Tell students, “During the presentations, you are going to take notes.” Have them turn to page 24 in their notebooks while you turn to page 5 of the picture packet. Tell them, “You will need to record each subgroup’s changing variable, as well as what data they have collected after the subgroup says their question. In addition, when the group presents their graph, you will need to record the values of the changing variable, as well as the corresponding measurements collected by the group.”

Tell students, “You will get to ask questions after the presentations. These questions are important because you will have to summarize what you learned from the subgroup and record that in your notebook. 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.”

Student notebooks only have room for notes on 8 presentations. Therefore, they will not take notes on their own presentation.

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 four 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 shadows?” 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 taller the block height, the longer the shadow but the shadow width stays the same.
- The wider the block width, the wider the shadow but the shadow length stays the same.
- The longer the block length, the longer the shadow but the shadow width stays the same.
- As the light height increases, the shadow length and width decreases.
- As the light distance increases, the shadow length increases but the shadow width stays the same.
- The closer the light angle is to 90°, the longer and thinner the shadow.

When summarizing experiments, use student-collected data and not what they should have found from the list above. Ask students, “If you want to get the longest shadow, what values of the variables should you use?”

- Block Height: As tall as possible
- Block Width: Any width
- Block Length: As long as possible
- Light Height: As low as possible
- Light Distance: As far out as possible
- Light Angle: 90°

Ask students, “If you want to get the widest shadow, what values of the variables should you use?”

- Block Height: Any height
- Block Width: As wide as possible
- Block Length: Any width
- Light Height: As low as possible
- Light Distance: Any distance
- Light Angle: Close to 0° or 180°
If no one in the class did experiments on one of the variables above, then they will not know how that variable affects the shadow length/width, and do not expect them to tell you which value to use. Tell students, “You have taught me a lot about shadows.”

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 them 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 8: Conclusion Assessment/Tie to Standards

Schedule:

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

Materials:

Lead Box:

- (3) Extra student notebooks
- Student notebooks
- Lead instructions
- Shadows picture packet
- Lead lab coat
- (35) Conclusion Assessments
- Time card
- (2) Pencils
- (2) Wet erase markers
- (35) Red pens
- (3) Rulers
- 7 cm block
TIE TO STANDARDS

1. Using the given information for each experiment, draw the shape around your prediction of what will happen to the shadow length and width. Once you have seen the pictures of the experiment draw a box around what actually happened to the shadow length and width. For all the experiments a 5 cm x 7 cm x 3 cm block was used.

Experiment 1: Effects of Changing Light Color

What will happen to:
- Shadow length
- Shadow Width

Experiment 2: Effects of Changing Light Height

What will happen to:
- Shadow length
- Shadow Width

Experiment 3: Effects of Changing Light Distance

What will happen to:
- Shadow length
- Shadow Width

Experiment 4: Effects of Changing Light Angle

What will happen to:
- Shadow length
- Shadow Width

2. What is the most important light source in your life? the sun
3. The sun rises in the ___east___ and sets in the ___west___.
4. What causes the changes in the sun’s position throughout the day? The Earth is rotating.
5. Draw the sun’s position and the corresponding shadow for each of the following times:
   - A: Sunrise
   - B: Midmorning
   - C: Noon
   - D: Afternoon
   - E: Sunset

6. What time(s) of day are shadows the longest? sun rise and sunset
7. What time(s) of day are shadows the shortest? noon
8. Using what you have learned about shadows, make a line graph showing how shadow length changes over the course of 24 hours in the summer. Use a red line to show your predicted values and a pencil line to show the actual data.

9. Using what you have learned about shadows, make a line graph showing how shadow length changes over the course of 24 hours in the summer. Use a red line to show your predicted values and a pencil line to show the actual data.

10. What conclusion can you make from the graphs about the amount of daylight throughout the year?
    We can conclude that the number of daylight hours in the summer is ___more___ than in the winter because in the summer there were ___14___ hours of daylight, in the winter there were ___10___ hours of daylight.

11. Using the sundials below, determine what time of day it is (morning/noon/afternoon).
    What time of day is it? noon
    What time of day is it? morning
    What time of day is it? afternoon
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 Conclusion 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 26-28, student notebook and pages 6-11, picture packet). If the classroom does not have a document camera, then tape the poster-size notebook pages to the front board.
4. Put your lab coat in the lead box at the end of the day.

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

“Before we start our activity today, we will determine how your ideas on conclusions are developing.” Have students write their name, teacher’s name, and date on 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 assessments.

For page 1 (top), read questions 1 and 2 aloud and give students time to answer each before moving on to the next question.

For page 1 (bottom), read the instructions to the students. Then, read each of the statements and tell the students to circle whether the statement is a claim, data, or opinion.

For page 2, have students circle the changing variable(s), underline the controls, and box information about data collection on the results table. Then, have them decide if the group could make a conclusion.

Read step 1 of the instructions aloud to students (Identify the following statements as either CLAIM or DATA and write a C or D on the line.). Then, have students fill in whether they think statement “a” is a claim or data by writing a C or D on the line. Tell students, “This part is similar to page 1 of the assessment.” Read step 2 of the instructions aloud to students (Look at the results table and circle if the statement is a correct claim, correct data, or incorrect. Statements are INCORRECT if the statement does not agree with the results table or has not been tested). Point to the results table and have students circle what they think is the correct answer for statement “a.” Once students have completed statement “a,” read statement “b” aloud and tell students, “Write a C or D on the line depending on if you think the statement is a claim or data.” After about 15 seconds tell students, “Now look at the results table and circle whether the statement is a correct claim, correct data or incorrect. Repeat the process for statements c-e.

For page 3, repeat the process.

For page 4, question 8 tell students, “You are going to write a conclusion, or summarize what a scientist learned, by collecting the following data.” Point at the results table. Read the directions aloud to students and give them a few minutes to try and write a conclusion. When students are finished, collect the assessments and verify that the students’ names are written on the top.
**Tie to Standards:**
(50 minutes – Full Class – SciTrek Lead)

**Effects of Changing the Light (15 minutes)**

Tell students, “Today you are going to talk about your previous experiments and hopefully answer any questions that you may still have about what variables affect shadows.” Have students turn to page 26 in their notebooks. Tell students, “We are going to look at four experiments and compare the lengths and widths of the shadows to one another. The four experiments that we will look at are light color, light height, light distance, and light angle. For all experiments, a 5 cm × 7 cm × 3 cm block was used.”

Tell students, “For the first experiment, we are going to explore how changing light color affects the shadow when the light height is 20 cm, the light distance is 10 cm, and the light angle is 90°. When the light color is changed from orange to blue, circle whether you think the shadow length will be shorter, stay the same, or be longer and whether the shadow width will be thinner, stay the same, or be wider.” Once students have finished their predictions have a student share their idea and have students use thumbs up/down to show if they agree or disagree. Show students the experiment 1 picture (page 6, picture packet, shown below). Ask students, “When the light color changes, what happened to the shadow length and width?” Tell students, “Do not erase your predictions, but put a box around the correct answers.” On the class notebook box “same” for shadow length and shadow width.

![Experiment 1: Effects of Changing Light Color](Page 6, Picture Packet)

Tell students, “For the second experiment, we will explore changing light height. For this experiment, we will use the same block as the previous experiment, a light distance of 10 cm, a light angle of 90°, and we will use white light instead of colored light. When the light height is increased from 20 cm to 60 cm, circle what you think will happen to the shadow length and width.” Once students have finished their predictions, have a student share their idea and have students use thumbs up/down to show if they agree or disagree. Show students the experiment 2 picture (page 7, picture packet, shown above). Ask students, “When the light height increased, what happened to the shadow length and width?” Tell students, “Do not erase your predictions, but put a box around the correct answers.” On the class notebook, box “shorter” for shadow length and “thinner” for shadow width.

![Experiment 2: Effects of Changing Light Height](Page 7, Picture Packet)

Tell students, “For the third experiment, we will explore changing light distance. For this experiment, we will use the same block as the previous experiments, white light, a light height of 20 cm, and a light angle of 90°. When the light distance is changed from 10 cm to 60 cm, circle what you think will happen to the shadow length and width.” Once students have finished their predictions, have a student share their idea
and have students use thumbs up/down to show if they agree or disagree. Show students the experiment 3 picture (page 8, picture packet, shown below). Ask students, “When the light distance increased, what happened to the shadow length and width?” Tell students, “Do not erase your predictions, but put a box around the correct answers. On the class notebook box “longer” for shadow length and the “same” for shadow width.

**Note:** If students do not believe that the widths are the same use the rulers in the lead box to measure the shadow width.

Tell students, “For the fourth experiment, we will explore changing light angle. For this experiment, we will use the same block as the previous experiments, white light, a light height of 20 cm, and a light distance of 10 cm. When the light angle is changed from 90° to 150°, circle what you think will happen to the shadow length and width.” Once students have finished their predictions, have a student share their idea and have students use thumbs up/down to show if they agree or disagree. Show students the experiment 4 picture (page 9, picture packet, shown above). Ask students, “When the light angle increased, what happened to the shadow length and width?” Make sure by the end of the conversation, students understand the shadow will always be in line with (or 180° from) the light source. Tell students, “Do not erase your predictions, but to put a box around the correct answers.” On the class notebook, box “shorter” for shadow length and “wider” for shadow width.
Connection to the Sun (10 minutes)

Tell students, “Now that you understand how to predict what shadows will look like, you will connect these predictions to other uses.” Have students turn to page 27 in their notebooks and ask them, “What is the most important light source in your life?” They may answer the lights in their home. Lead students to understand the lights in their home are useful, but humans have lived without them in the past, so if needed, people could live without them again. However, there is one source of light no one would be able to live without. The light source that is most important in all of our lives is the sun. Have students fill this out in their notebooks.

Next, ask students, “Which direction (north, south, east, or west) does the sun rise and which does it sets in?” Possible student response: the sun rises in the east and sets in the west. Have them fill this in for question 3 in their notebooks. Then ask them, “What causes the change in the sun’s position throughout the day?” Lead the students to understand the sun is not moving, but the Earth is rotating, causing it to look like the sun is moving. Then have them record this in their notebook for question 4.

Tell students, “Now that we understand where the sun rises and sets, as well as what a shadow will look like for a corresponding light source, you are going to draw a picture showing where the sun will be and what the shadow will look like for the sunrise, midmorning, noon, afternoon, and sunset.” With the students, draw in the location of the sun for each of the points. Have the students draw the suns in the following order: A (sunrise), C (noon), E (sunset), D (afternoon), B (midmorning). Draw in the shadow for A
(sunrise) then have students try to fill in the remaining shadows in their notebooks. Have one student volunteer to share their shadow placement with the rest of the class. Put that student’s notebook under the document camera and have the rest of the class discuss the placements of the shadows and if they agree or disagree with the placements. Once a consensus is reached, draw the shadows into the class notebook. Make sure by the end of the conversation, students understand that the shadow will initially be in the west and very long, at approximately noon the shadow will be the shortest and right before sunset the shadow will be very long and in the east. An example is shown below.

![Diagram of sun's position and corresponding shadow]

After completing the picture, ask students, “What time of day are shadows the longest, and when are they the shortest?” Students should see shadows are longest at sunrise and sunset, when the sun is low, and shortest at noon, when the sun is directly above the objects. Next, ask students, “Why do you think this is?” Possible student response: during sunrise and sunset the light source is coming from the side of the object rather than directly above. As we have learned earlier, when the light is coming from a low light height the shadows are longer. A low light height could represent the sunrise and sunset. We also learned that a high light height will lead to a short shadow. A high light height could represent noon.

![Sentences about shadow lengths]

Seasonal Shadows (23 minutes)

Pass out a red pen to each student.

Tell students, “You are now going to graph how you think the shadow length of an object changes over the course of 24 hours, in the winter.” Ask students “What is the first point on the graph?” Students should reply, “Midnight”. Ask students “What does it look like outside at midnight?” Students should reply, “Dark.” Ask students, “If it is dark will there be a shadow?” Students should reply, “No.” Tell students this means that our first point will have a shadow length of 0. Put a red dot at 0 shadow length at midnight. Ask students, “What they think the shadow length will be at 2:00 am and why?” Possible student response: 0 because it is still dark. Put a red dot at 0 shadow length at 2:00 am. Tell students, “You will now predict the shadow length for the rest of the 24-hour period. Put down dots for each time and then connect the dots. Therefore, if you thought the shadow length was 0 for the entire 24-hour period, your graph would look like a straight line at 0.” Show them what this would look like on the class notebook (shown below). Ask students, “Is this prediction correct?” They should reply, “No.”
Once students have had a chance to complete their predictions, pick one student to show their prediction under the document camera. Have students give critiques of the graph. In addition, you should ask questions to help guide student thinking.

Tell students, “You will now graph the actual data showing how shadow length changes with time during the winter using your pencils and not the red pen.” Show students the results table while reading it to them (page 10, picture packet, shown below (left)). In addition, plot the data points in the class notebook. Draw in a solid line connecting the points. Ask the class the following questions:

- Why are the data points all zero between midnight and 4 am?
  - It was night so there was no shadow.
- What time does sunrise occur and how do you know?
  - It occurs at approximately 7 am because this is the first time a shadow was seen.
- Does shadow length change faster in the morning or closer to midday?
  - Shadow length changes faster in the morning and evening and slower as it approaches midday.
- What time was the sun directly overhead?
  - The shadow length was 0 at 12 pm, therefore, the sun must have been directly overhead at this time.
- How many hours passed between the time that the sun rose and the time the sun was directly overhead?
  - 5 hours
- How much time passed between the time the sun was directly overhead and the time the sun set?
  - 5 hours
- Is the graph symmetric?
  - Yes
- How many hours of daylight are there during the winter?
  - 10 hours

<table>
<thead>
<tr>
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<th>Shadow Length</th>
</tr>
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<tbody>
<tr>
<td>12:00 am</td>
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</tr>
<tr>
<td>2:00 am</td>
<td>0</td>
</tr>
<tr>
<td>4:00 am</td>
<td>0</td>
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<tr>
<td>6:00 am</td>
<td>0</td>
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<tr>
<td>7:00 am</td>
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<tr>
<td>8:00 am</td>
<td>2</td>
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<td>10:00 am</td>
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<td>12:00 pm</td>
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<td>12:00 pm</td>
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8. Using what you have learned about shadows, make a line graph showing how shadow length changes over the course of 24 hours in the winter. Use a red line to show your predicted values and a pencil line to show the actual data.
Ask students, “Would a graph of shadow length vs. time be the same for all times of the year?” Students should reply, “No.” On question 9 have students draw a red line to show their predictions of what a graph of shadow length vs. time would look like during the summer. Once students have had a chance to complete their predictions, pick one student to show their prediction under the document camera. Have students give critiques of the graph. In addition, ask questions to help guide student thinking. Collect the red pens.

Tell students, “You will now graph the actual data showing shadow length vs. time during the summer using your pencil.” Show students the data table while reading it to them (page 11, picture packet, shown below (left). In addition, plot the data points in the class notebook. Draw in a solid line connecting the points. Ask students the following questions:

- How many hours passed between the time that the sun rose and the time the sun was directly overhead?
  - 7 hours
- How much time passed between the time the sun was directly overhead and the time the sun set?
  - 7 hours
- Is this graph symmetric?
  - Yes
- How many hours of daylight are there during the summer?
  - 14 hours

**How Shadow Length Varies in the Summer**

<table>
<thead>
<tr>
<th>Time</th>
<th>Shadow Length</th>
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<td>12:00 pm</td>
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**Note:** The reason that the sun is not overhead at noon is because of daylight savings time (DST). Do not bring this up with students unless they ask specifically about this. DST shifts our clocks one hour later in the day. We are on DST from March through November.

**Note:** Shadows are longer in the winter than in the summer because of the tilt of the Earth. During the winter, the tilt of the Earth causes the sun to be lower in the sky than during the summer, making the shadow longer. See picture below. Do not bring this up with students unless asked.
Ask students, “What conclusion can we make about the number of daylight hours throughout the year?” Have one student share what they think the conclusion will be and once a class consensus is reached, record the conclusion in the class notebook and have students copy it into their notebook. Ask the class, “What part of the conclusion was the claim and how do you know?” Possible student response: the number of daylight hours in the summer is more than in the winter is the claim because it is a statement that we can test. Ask the class, “What part of the conclusion is the data and how do you know?” Possible student response: in the summer there were 14 hours of daylight and in the winter there were 10 hours of daylight is the data, because it contains measurements.

**Sundials (2 minutes)**

Tell students, “In the past, before there was electricity, people relied on the sun to determine what time of the day it was. One method of doing this was by using a sundial. Sundials are set so that their gnomons (piece that sticks up out of a sundial) point to the north. People who know and understand the properties of shadows can determine the time of day by looking at the shadow on the dial plate. We will use the three sundials in your notebooks to determine what direction (east/west/directly above) the sun is coming from as well as what time of day it is (morning/noon/afternoon).”

**Note:** Sundials are made for a specific latitude to account for the actual distance the sun is away from the location it is being used. If you know the latitude that your sundial is made for, you can make mathematical corrections to find the time for your latitude if the two are different. Additional corrections need to be made in areas where there is daylight savings time. Do not bring this up with students unless asked.
Tell students, “You have taught me a lot about shadows. I now know that the larger the light distance, and the smaller the light height, the longer the shadow. In addition, I saw that the shadow is always 180° from the light source. Knowing these facts about shadows has allowed me to see how shadows can be used to tell time.”

Tell students, “You can keep your notebook. 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 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: