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)

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 10-11 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, to perform their experiments. Students stay in these subgroups for the rest of the module. One volunteer is assigned to help each of the groups (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 that 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 and placement given the location of a light source (including the sun) and an object.
3. Students will know that 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 that they can only have one changing variable 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), to perform experiments.
1. Module 1 & 2 (year 1)
   a. Classroom Teacher Leads a Group
2. Module 3 & 4 (year 2)
   a. Classroom Teacher Co-Leads the Class (an experienced SciTrek volunteer will be present to help out if needed)
      i. Classroom teacher will be responsible for leading entire class discussions (examples: conclusion activity, Tie to Standards, etc.).
      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.
3. Any Additional Modules (year 3 and beyond)
   a. Classroom Teacher Leads the Class
      i. Classroom teacher will be responsible for leading entire class discussions (examples: conclusion activity, Tie to Standards, etc.).
      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.

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 scitrekadmin@chem.ucsb.edu to learn more.

In addition, teachers are required to come to UCSB for the module orientation, ~one week prior to the start of the module. Contact scitrekadmin@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 ~10 students to sit. This ensures that students can begin the module as soon as SciTrek arrives. The desk/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 ~3 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 (~one week before your module, exact orientation times are found at: [http://www.chem.ucsb.edu/scitrek/elementary](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 discussion

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. Wooden Blocks (height: 2 cm, 3 cm, 4 cm, 5 cm, 6 cm, 7 cm, 8 cm, 9 cm, 10 cm, for all blocks the widths are 7 cm and thicknesses are 3 cm) These blocks are cut to size from 2x 4’s.
7. Support Stand with Rod (Spectrum Chemicals and Laboratory Products Part Number: 141-77765-E1)
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: 599452)
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 scitrekadmin@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.

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 this day. 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**
- Introduction (SciTrek Lead) – 2 minutes
- 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
- (35) Conclusion assessments

Time card
- (2) Pencils
- (2) Wet erase markers
- (3) Markers (orange, green, blue)
- (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
**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 swing 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 swing arm.
4. Identify the angle of the flashlight in relation to the box.

**OBSERVATIONS**

Experimental Set-Up:
- Block height = 5 cm
- Block width = 7 cm
- Block length = 3 cm
- Light angle = 60°
- Flashlight painted at block

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

<table>
<thead>
<tr>
<th>Light Height (cm)</th>
<th>Light Distance (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>10</td>
</tr>
<tr>
<td>45</td>
<td>15</td>
</tr>
<tr>
<td>40</td>
<td>20</td>
</tr>
<tr>
<td>35</td>
<td>25</td>
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<tr>
<td>30</td>
<td>30</td>
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<td>25</td>
<td>35</td>
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<tr>
<td>20</td>
<td>40</td>
</tr>
<tr>
<td>15</td>
<td>45</td>
</tr>
<tr>
<td>10</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>55</td>
</tr>
<tr>
<td></td>
<td>60</td>
</tr>
</tbody>
</table>
**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:</td>
<td>1.5 cm</td>
<td>1.5 cm</td>
</tr>
<tr>
<td>Shadow Width:</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 longer the shadow. This will not affect the shadow width.</td>
</tr>
<tr>
<td>Light Distance</td>
<td>The farther out the light source, the longer the shadow.</td>
</tr>
<tr>
<td>Light Angle</td>
<td>The closer the angle is to 90°, the longer the shadow.</td>
</tr>
<tr>
<td>Light Height</td>
<td>The higher up the light source, the shorter the shadow.</td>
</tr>
<tr>
<td>Block Width</td>
<td>The block width will not affect the length of the shadow. Wider blocks will make wider shadows.</td>
</tr>
</tbody>
</table>

Choose your own!
Set-Up:

SciTrek Lead:
If the classroom has a document camera, ask the teacher to use it for the class question (front cover, student notebook), the technique activity (page 2, student notebook), and the block measurement pictures (page 1 and 2, picture packet). If the classroom does not have a document camera, then tape the example poster-size notebook page to the front board and write the class question on the board during the module introduction.

On the board, write the three group colors (orange, blue, and green) and the name(s) of the volunteer(s) that will be working with each group.

SciTrek Volunteers:
Put your name, the teacher’s name, and your group color on the top of your group notepad.

As soon as you get into the classroom, pass out students’ nametags, which are in your group box.

Once you have passed out the nametags, assemble the experimental set-up (shown in picture below as well as in the experimental set-up picture in your group box) on a spot on the floor where “ten students can sit. Use the following steps to help you with the set-up:
1. Attach the pole to the ring stand base by screwing them together.
2. Attach the clamp to the ring stand pole at a height of 35 cm.
3. 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 that the front of the clamp and the head of the flashlight are touching (see enlargement in picture below).
4. Make sure that 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.
5. Place the white plastic mat on the floor so that one of the short sides of the plastic is closest to the ring stand.
6. Place the 5 cm block on the short side of the white plastic in the center.
7. Place a 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.
8. 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.
9. Make sure that the flashlight is in line with the protractor.
10. 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.
11. Place the three rulers on the white plastic.
12. Place the flashlight without a filter and ten clipboards next to the experimental set-up.
Be prepared to pass out student notebooks and protractors. The notebooks/protractors can be given to any student, not just the students in your group.

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.” Pass out the conclusion assessment and tell students to fill out their name, teacher’s name, and date at the top of the assessment. Remind the students that it is important that they fill out this assessment on their own.

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

For page 2, tell the students that we are going to do the first part 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). Tell students that because the time is different in trial 1 and trial 2, time is the changing variable. Under the document camera circle time on the results table and have students do the same. Then tell students that because the rest of the variables are the same for trial 1 and trial 2, the rest are controls. Under the document camera underline shoe type, trail type, and number of stops on the results table and have students do the same. Show students where the data is recorded on the table and box distance travelled and sock cleanliness. Then have them individually decide if the group could make a conclusion.

Read step one of the instructions to the students (identify the following statements as either CLAIM or DATA and write a C or D on the line). Then have students fill in if they think statement “a” is a claim or data by writing a C or D on the line. Tell students this is similar to page 1 of the assessment. Read step two of the instructions to the 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 they have completed statement “a” move on to the next statement. Read each statement aloud and tell students to write the appropriate letter on the line then circle if the statement is a correct claim, correct data, or incorrect.

Repeat the process for page 3 including underlining, circling, and boxing the results table as a class. Read the question at the bottom of page 3 to students and have them fill in the blank. When they are finished, collect the assessments and verify that the students’ names are on the papers.
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 notebook. 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 gets into groups for observations and they can fill out their group color and volunteer at that point.

Tell the class that we are going to investigate shadows. Ask the class what shadows are and what causes them. By the end of the conversation make sure that 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 if one object can make different sized/shaped shadows. By the end of the conversation make sure that students understand that 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 changes shadows sizes. 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 example notebook under the document camera and have students copy this question onto the cover of their notebooks.

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

As soon as students write the class question on the front of their notebook, volunteers should pass out a protractor to each student.

Tell the class that 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 an example notebook under the document camera. Review the parts of the protractor while pointing to each part on an example protractor. Tell students that 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 wood block. The baseline is where the start of the inner and outer scales meet and will be lined up in parallel with the base of the reference object (wooden block). To measure an angle, the protractor is put on one 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 the 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 that it is okay if their answers differ by up to 3° (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, volunteers should collect the protractors.

Tell students that now that they know how to use a protractor to measure angles, they will be able to use these skills to determine what angle the light is coming from to create a shadow. Inform them that they are going to make some observations of a shadow system, but before we do this we need to understand observations.
**Observation Discussion:**
*(4 minutes – Full Class – SciTrek Lead)*

Tell the students that 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, material, etc. Lead students to understand that an observation is a description using your five senses.

“In this experiment we are going to make observations of a shadow made from two different light colors.” Tell the students that they will need to measure the length and the width of the shadow. 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 shadows picture packet under the document camera (shown below on the 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 (shown above on the right) and walk the 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 they will now get in their groups and make observations. To determine their group, they will need to look at the color of their 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 the 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 clipboards to each student and then have them turn to page 3 of their notebook.

As a group, have the students generate ~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 graph and then copied by student 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. See example notebook below for possible experimental set-up observations; feel free to deviate from the example.

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 extra time**, have the 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 group notepad/student notebook is shown below. Feel free to deviate from the example.

**Variable Discussion:**
*(5 minutes – Full Class – SciTrek Lead)*

Ask the class questions to review, the experiment that they did 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 object 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 them which light source they think we should use for other experiments and why? They should say 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 the 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 that they are going to think about variables in the experiment that they could change to help us answer the class question. In addition to generating variables, they should think about how/why these variables might affect the outcome of the experiment. Ask the class to give you a variable that they think might affect the size (length and width) of the shadow; then have them tell you how/why they think that variable would affect the experiment. 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 that predictions can be wrong, and we will not know the correct answers until we carry out the experiment.

Example:  
  **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 they will now generate more variables and analyze them in their 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 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 this variable 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 the students that the next time we meet they will design an experiment to answer the class question (What variables affect shadows?).

**Clean-Up:**

Before you leave, have students attach their nametag to their notebook and place them in the group box. Take the ring stand apart. Put all of the materials into your group box, except the clipboards and pole for the ring stand. Bring all materials back to UCSB. In addition, put your lab coat into your group box. If you would like to divide your group (~ten students) into three subgroups, you can do this by writing a “1,” “2,” or “3” on the top of each student’s notebook to designate their subgroup. Make sure that the subgroups are made up of mixed gender and mixed ability students.
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

☐ Volunteer lab coat
☐ (3) Materials pages (subgroup color & number indicated)
☐ (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, green, blue)
☐ 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 white light and the light must be focused and pointed directly at the center of the black block.
3. All objects will be rectangular wooden 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) (max three) that you would like to test. For each changing variable that you select, discuss with your group why you think that variable will affect the shadow.

Changing Variable 1: light distance
Discus with your group how you think changing variable 1 will affect the shadow.

Changing Variable 2 (optional): light angle
Discus with your group how you think changing variable 2 will affect the shadow.

Changing Variable 3 (optional): block width
Discus with your group how you think changing variable 3 will affect the shadow.

What will you measure? (circle one)
- Shadow Length
- Shadow Width

Question our group will investigate:
- If we change the light distance, light angle, 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.

EXPERIMENTAL SET-UP
Determine the values of your changing variable(s) (exc block height) from the materials page and write the values (exc cm) for your four trials under each block.

Changing Variable(s):
- 1) light distance: 25 cm 60 cm 10 cm 45 cm
- 2) light angle: 30° 30° 90° 20°
- 3) block width: 1 cm 2 cm 10 cm 1 cm

Controls (variables you will hold constant):
Determine the variable that you will hold constant and indicate the specific value you will use in all your trials.

Light Color: White light height: 25 cm
block height: 1 cm surface: white plastic block length: 3 cm block material: wood

SciTrek Member Approval:
Set-Up:

SciTrek Lead:
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 example poster-size notebook pages to the front board.

SciTrek Volunteers:
Set out student notebooks to allow students in the same subgroup (same number on front of notebook) to work with each other.

- If students are not in the classroom before SciTrek starts, set out the notebooks where students should sit when they come into the classroom.
- If students are in the classroom before SciTrek starts, set out the notebooks where students should sit during the module; they will move to these spots after the introduction.

Make sure you have three materials pages, each filled out with a subgroup number (1, 2, or 3) and your group’s color. These will be given to students after they complete their question.

Have a red pen available to approve students’ question, experimental set-up, and procedure (pages 6, 7, and 8).
Introduction:
(13 minutes – Full Class – SciTrek Lead)

If needed, while you are doing the introduction have volunteers set out the notebooks/nametags where they would like students to sit. Make sure that students in the same subgroup are sitting next to each other. Tell students that a notebook will be put on their desk, which is not their notebook and they should not move it.

Ask students what they did during the last meeting with SciTrek. They should reply that they did an experiment in which they changed the light color (colored and white light) and observed the shadow that a wood block cast. They learned that the color of the light does not affect the size of the shadow. In addition, they generated other variables that might affect shadows. Ask the class if they remember the class question they will investigate. They should reply, “What variables affect shadows?”

Tell students that one way scientists answer questions is by performing experiments; today they will design an experiment to help answer the class question. Ask the class if they think there are multiple variables that could affect shadows. They should respond that there probably are multiple variables. 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 that they need to keep a few things in mind when they 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 wooden blocks and you will only be able to change one dimension of the block.

When you tell students experimental consideration 2, show students the two example blocks and tell them that two of their block dimensions must be 7 cm and 3 cm but they can rotate their block so that they 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 and that you will write it in an example notebook so that they will be able to refer back to it when they are completing the process themselves. 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 example notebook (page 6) under the document camera. Tell students when they are going through this process in their subgroups, they can select one, two, or three changing variable(s).

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 that they will then select if they will measure the shadow length or width. Suggest that if think they know what will happen to one of these, they might select the opposite to measure. For example, if I thought that I knew how block height affected the length of the shadow, I might pick 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? Explain to students that many times when there is a large question, like our class question, scientists break it down into smaller questions that individual scientists can investigate, and then they compile their work to answer the large question.

Show students the materials page (lead box) and read the first step (Go through the bolded words and circle if it is a changing variable and underline if it is a control.) 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, select 1 value. For variables that are changing variables, select 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 (example: “60°” for “light angle”). Assign each control value to a student and tell them they are in charge of remembering that control and
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 if 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 if these values would allow them to best answer their question. Allow them to change their values if needed. Assign the changing variable values to the students who chose them to help when filling out the experimental set-up.

When selecting the block, remind them that only one of the block dimensions can be a changing variable. Tell them that if one of the block dimensions is a changing variable this needs to go on the first line under the block on the materials page. If all of their block dimensions are controls, they can select any block dimension they would like to choose the dimension of and put it on that line. They 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 student how to use the chart. Tell them that they can select any light location as long as it is not greyed out. Show them how 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) tell them to leave the line blank. Then read students the instructions directly above the graph and ask the following questions:

- **If you have no circles you can select/mark any value that is not greyed out.**
  - Ask students if this is our case. They should respond no. Tell students if it was, they could put their 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 if this is our case. They should respond 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 we saw 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 that once they have completed their materials page, they will fill out their experimental set-up (page 7, student notebook). First, they will fill out the information on the changing variable(s). Ask students what the changing variables were for our example experiment and fill in the values for trials A and B only. Second, they will fill in information about the controls. Draw an additional control line under the existing control list. Ask students for one of the controls for the example experiment. Show students how to record the control on the left side of the slash (example: light color) and the value of that control on the right side of the slash (example: 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 that they may need to generate two additional variables that do not come from the materials page. Lead students to realize they should be surface/white plastic and block material/wood.

Ask students if everyone should choose the same changing variable. They should respond no, because they will not learn as much about the class question. Once their subgroup has completed their experimental set-up, they should raise their hands and get it approved by their SciTrek volunteer. Below is an example of what should be filled out for the example 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 they finish their experimental set-up, they will write a procedure for their experiment that they will be able to follow next time. When writing a procedure, they should write all the values of their changing variable(s) and controls 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.). Once their procedure is completed, they will get it approved by a SciTrek volunteer.

Place the class example question under the document camera so that students can refer back to it as they design their experiment. As subgroups move onto their experimental set-up, put the example experimental set-up 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, or 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. Each subgroup should briefly discuss how/why they think each changing variable will affect the shadow.

After subgroups have decided on their changing variable(s), have them decided 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 of a 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 changing variable(s) and controls. For the changing variable(s) values, have students write the trial letter next to the value they select. Ask students to justify the values that they have chosen for their changing variable(s) and controls and if these values will make it easier or harder to answer their question.

Make sure that 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:
(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 bock material wood. When you sign off on their experimental set-up, collect the materials page and verify that it is filled out correctly and completely. Having the materials page filled out is essential for students to start their experiments during the next SciTrek visit. An example of an 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 the students have finished, they should raise their hand and get their procedure approved by their SciTrek volunteer. An example 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 that on the next SciTrek visit they will start their experiments. Tell students that all of their experiments will help us answer the class question: what variables affect shadows?

**Clean-Up:**

Before you leave, have students attach their nametag to their notebook and place them in the group box. Place the materials pages on top of the notebooks in your group box. Bring all materials back to UCSB. In addition, put your lab coat into your group box.
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
- ☐ Picture of Experimental Setup
- ☐ Volunteer lab coat
- ☐ (2) Pencils

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 Setup
- ☐ 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) wooden blocks – one of each size)
- ☐ White plastic surface
**Set-Up:**

**SciTrek Lead:**

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 example poster-size notebook pages to the front board.

**SciTrek Volunteers:**

- Set out student notebooks.
  - If students are not in the classroom before SciTrek starts, set out the notebooks where students should sit when they come into the classroom.
  - If students are in the classroom before SciTrek starts, set out the notebooks where students should sit during the module; they will move to these spots after the introduction.

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 on the lowest place on the ring stand to allow students to put the clamp at the appropriate height(s) when they do their experiment.

Place subgroup bags, white plastic, and ring stands in three unique spots on the floor along with four clipboards.

**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 needed, while you are doing the introduction have volunteers set out the notebooks/nametags where they would like students to sit. Make sure that students in the same subgroup are sitting next to each other. Tell students that a notebook will be put on their desk, which is not their notebook and they should not move it.

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

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

Tell the students that once they have collected their data, they will display their measurements on a graph (page 10, student notebook). Show them how to make a graph using 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 on the left), and put it under the document camera. When graphing the example data, only graph the first two data points. Tell the students that the question for the example experiment was, “If we change the block height and light distance, what will happen to the length of the shadow?” Tell students that in order to make a graph, you will need to follow the checklist on the top of page 10 of the notebook.
Set-up your graph.
Tell students that first we need to set-up the graph before we can plot the data. Remind students to check off each step after they complete it.

☐ Write what you measured (example: shadow length (cm)) on the y-axis (vertical).
Tell students that because your question was about shadow length, you 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 that 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 if we would be able to fit this shadow length on the graph if we counted by ones. The students should respond no. Then ask them what we should count by in order to make sure that the longest shadow’s length will fit on the graph (by fives). When students make their own graphs, they should only count by ones, twos, or fives. Put the numbers on the graph, making sure that they know to start counting at zero. Make sure that 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.

☐ Write your changing variable(s) #1, #2, and #3 (example: block height) on the x-axis title (horizontal). Changing variable #2 and #3 will only be filled in if you have 2 or 3 changing variables.
Ask students what the changing variables were in this experiment. Students should respond 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 that 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 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 that now that they have determined the order in which they will graph their data, they need to plot their data in increasing order. To do this, there are a few steps that they need to follow.

☐ Write the changing variable value(s) (example: 5 cm) for the trial that you labeled 1 under the first column.
Ask students which trial was labeled 1 (Trial A). Then ask them what you should write next to block height and light distance for the first trial. Write “5 cm” for block height and “10 cm” for light distance on the example notebook.

☐ Graph your data for that trial and write the measurement above the bar.
Ask students what shadow length will be graphed for trial A (5 cm). Put your finger at zero and tell the students to tell you to stop once you 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 to look at how fast you filled in the chart and challenge them to fill in their graph faster than you when they graph their own data.

☐ Repeat the process for the other trials.

Ask students what the values for the changing variables are for the trial that we will graph next. Write 3 cm for block height and 45 cm for light distance on the example notebook. Ask them what the shadow length is for this trial (23 cm). Have students help you identify where 23 cm is, draw a line, and write the numeral value over the line. Tell students that you will only graph the first two data points, but in their subgroups, they 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 that the picture packet will represent the white plastic and the light source would be in front of the block. Ask the students what we call the block dimension going up. They should respond height. Ask the students what we call the block dimension going across the front of the white plastic. They should respond width. Ask the students what we call the block dimension going away from the light. They should respond length. Show students that if they forget the dimensions they can look at the picture at the top of their results table.

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, explain to those students that when measuring the length of the shadow they will line up the 0 cm mark of a ruler with the front of the block (front of the white plastic). They 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, explain to those students when measuring the shadow width they will place two rulers (numbers side down) perpendicular to the short side of the white plastic on either side of the shadow. They will then measure between the two rulers with a third ruler to find the shadow width resulting in the rulers making an “H.”

Tell students that they will now fill out their results tables and start their experiments. When they are done with their experiment, they can graph their results.

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

Have students underline the variables that are controls, circle the variables that are their changing variable(s), and box the 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; for the changing variable(s), they write the value in each of the boxes.

When students have finished, have them make predictions about the shadow lengths. Have them write a “B” in the box of the trial they think will produce the biggest shadow length/width and an “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. Try to question each subgroup on their thought process behind their predicted shadow lengths/widths. See an example notebook in Experiment section below (left).

**Experiment:**
*(22 minutes – Subgroups – SciTrek Volunteers)*

Once subgroups have finished their results table, tell them where their supplies are on the floor. 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 (found in your box) to tape down their measuring tape so that it does not move. For these students, the measuring tape should go under the protractor. For groups 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. In addition, verify that 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 the students’ set-up, verify they have their block in the correct orientation. If the 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, use a measuring tape found in the lead box.

Make sure that the students are measuring the correct shadow dimension (length or width) stated in their question and that the shadow is being measured as described in the Set-Up 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 they 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 of a properly filled out results table is shown below on the left.
Graph:
(10 minutes – Subgroups – SciTrek Volunteers)

Help students fill out their graph by having them complete the checklist on page 10. Be sure that students label the y-axis with what they measured, either 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 the 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 this example, the trials were graphed in the following order: B, D, A, C. Once they have graphed their values, make sure that 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 of a properly filled out graph is shown above on the 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). Groups will move on to their second experiment after the conclusion activity and will present their second experiment to the class and, therefore, will not use the 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. Students that do not finish their graph can present their second experiment and, therefore, will not need their first graph.

If students are still sitting on the floor, have them return to their original class seats. Tell the students to turn to page 11 in their notebooks while you put the example notebook under the document camera and
turn to page 11. Mention that before they analyze their graph and draw a conclusion, it is important that they recognize and understand others’ conclusions.

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

Tell the students that 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 the students that a claim is a statement that we can verify by testing. Have the class generate approximately four examples of statements that are claims. After a student suggests a possible claim, ask the class if the possible claim can be verified by testing. Have students hold their thumb up if it is a claim and down if it is not. Then ask someone else in the class to propose how you would test this claim. Several examples are shown below.

**Examples:**
- Claim: rabbits are faster than mice
  Test: time rabbits and mice running a certain distance
- Claim: giraffes are taller than horses
  Test: measure the heights of horses and giraffes
- Claim: watermelons weigh more than pumpkins
  Test: weigh pumpkins and watermelons

Next, read the definition of data and the example. Note that 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 that data often contains a numerical measurement such as a height (5 m) or a weight (20 kg). Box the measurements in the data. Ask the students if data has to contain a numerical measurement. Explain that data can also be in the form of observations. For example, plants are observed to have greener leaves when in direct light rather than indirect light. When you want to identify if a statement is data, look for measurements or words such as recorded or observed that allow you to know that an experiment was performed. Tell students that when they see data in a statement, they should box it. Have students box 11 g and 5 g. Tell them that if it is observational data, they will box the word observed.

Ask the students if 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 approximately four examples of opinion statements.

**Example:**
- Watermelons taste better than pumpkins.
- Rabbits are cuter than cats.

Read the directions to part 2 aloud to the class. Tell students to look for clues in the statements to identify if it is a claim, data, or opinion. Work on the activity as a class. 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 an agreement, circle the correct answer on the example 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 can

**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, $\frac{1}{4}$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 extra 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 that on the next SciTrek visit they will analyze other scientists’ data to identify appropriate claims and data statements. They will then analyze their own data to see if they are able to draw a conclusion. After, they will get to design a second experiment.
Clean-Up:

Before you leave, have students attach their nametag to their notebook and place them in the group box. Bring all materials back to UCSB. In addition, put your lab coat into your group box.

**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
### SCIENTIFIC PRACTICES

#### Conclusions

3. Directions: Draw a line connecting claims with correct data. If there is no data that supports the claim, do not draw a line.

<table>
<thead>
<tr>
<th>Claim</th>
<th>Because</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. More people go to soccer</td>
<td>a. 1 ml of diet coke weighs 5 grams and 1 ml of coke weighs 1.1 grams.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>matches than basketball games</td>
<td></td>
</tr>
<tr>
<td>2. Spicy food causes heartburn</td>
<td>b. 51% of people get heartburn when they use hot sauce and not of people get heartburn when they don’t use hot sauce.</td>
<td></td>
</tr>
<tr>
<td>3. Cars increase air pollution</td>
<td>c. The air has been observed to be brown in areas with large numbers of cars.</td>
<td></td>
</tr>
<tr>
<td>4. Diet coke weighs less than regular coke</td>
<td>d. 10 people went to the movies while 15 went shopping.</td>
<td></td>
</tr>
</tbody>
</table>

### SCIENTIFIC PRACTICES

#### Conclusions

<table>
<thead>
<tr>
<th>Variables</th>
<th>Trial A</th>
<th>Trial B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light Color</td>
<td>White</td>
<td>White</td>
</tr>
<tr>
<td>Block Height</td>
<td>9 cm</td>
<td>9 cm</td>
</tr>
<tr>
<td>Block Width</td>
<td>7 cm</td>
<td>7 cm</td>
</tr>
<tr>
<td>Light Distance</td>
<td>30 cm</td>
<td>30 cm</td>
</tr>
<tr>
<td>Light Height</td>
<td>30 cm</td>
<td>30 cm</td>
</tr>
<tr>
<td>Light Angle</td>
<td>30°</td>
<td>40°</td>
</tr>
</tbody>
</table>

- **Final Observations/Measurements**
  - | Trial A | Trial B |
  - Shadow Length | 6 cm | 10 cm |

6. Directions: Decide if a claim/conclusion can be made for each of the following results tables and graph.

**Table A**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Trial A</th>
<th>Trial B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light Color</td>
<td>White</td>
<td>White</td>
</tr>
<tr>
<td>Block Height</td>
<td>8 cm</td>
<td>8 cm</td>
</tr>
<tr>
<td>Block Width</td>
<td>6 cm</td>
<td>6 cm</td>
</tr>
<tr>
<td>Light Distance</td>
<td>25 cm</td>
<td>25 cm</td>
</tr>
<tr>
<td>Light Height</td>
<td>30 cm</td>
<td>30 cm</td>
</tr>
<tr>
<td>Light Angle</td>
<td>30°</td>
<td>40°</td>
</tr>
</tbody>
</table>

- **Can this scientist make a claim/conclusion?** No

**Table B**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Trial A</th>
<th>Trial B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light Color</td>
<td>White</td>
<td>White</td>
</tr>
<tr>
<td>Block Height</td>
<td>8 cm</td>
<td>8 cm</td>
</tr>
<tr>
<td>Block Width</td>
<td>6 cm</td>
<td>6 cm</td>
</tr>
<tr>
<td>Light Distance</td>
<td>25 cm</td>
<td>25 cm</td>
</tr>
<tr>
<td>Light Height</td>
<td>30 cm</td>
<td>30 cm</td>
</tr>
<tr>
<td>Light Angle</td>
<td>30°</td>
<td>40°</td>
</tr>
</tbody>
</table>

- **Can this scientist make a claim/conclusion?** Yes

**Table C**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Trial A</th>
<th>Trial B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light Color</td>
<td>White</td>
<td>White</td>
</tr>
<tr>
<td>Block Height</td>
<td>8 cm</td>
<td>8 cm</td>
</tr>
<tr>
<td>Block Width</td>
<td>6 cm</td>
<td>6 cm</td>
</tr>
<tr>
<td>Light Distance</td>
<td>25 cm</td>
<td>25 cm</td>
</tr>
<tr>
<td>Light Height</td>
<td>30 cm</td>
<td>30 cm</td>
</tr>
<tr>
<td>Light Angle</td>
<td>30°</td>
<td>40°</td>
</tr>
</tbody>
</table>

- **Can this scientist make a claim/conclusion?** Yes
- **Can this scientist make a claim/conclusion?** No

- **Can this scientist make a claim/conclusion?** Yes
- **Can this scientist make a claim/conclusion?** No
**Set-Up:**

**SciTrek Lead:**

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 example poster-size notebook pages to the front board.
SciTrek Volunteers:
Set out student notebooks.
- If students are not in the classroom before SciTrek starts, set out the notebooks where students should sit when they come into the classroom.
- If students are in the classroom before SciTrek starts, pass out notebooks to them; they will move to their subgroup seats after the conclusion activity.

Make sure you have three materials pages, each filled out with a group number (1, 2, or 3) and your group’s color. These will be given to students after they complete their question.

Have a red pen available to approve students’ question, experimental set-up, and procedure (pages 17, 18, and 19).

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

If needed, have volunteers hand out the notebooks/nametags to the students in their seats. They will move into their subgroups after the conclusion activity.

Inform students that today they are going to match claims with appropriate data and then analyze others’ data to determine which claims and data are appropriate for a given set of results. Afterwards, they will analyze their own data to see if they can make a claim/conclusion. They will then have the opportunity to design a second experiment or redesign their first experiment, which will be carried out during the next SciTrek visit.

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

Tell the students to turn to page 12 in their notebooks. Place an example notebook under the document camera and open to page 12.

Ask students what types of statements are needed to make a conclusion. Students should tell you that a conclusion is made from a claim and a supporting data statement. Ask students for the definition of a claim. Students should remind you that a claim is the explanation of your data; a statement that can be verified by testing. Ask students what type of information can be used for data. Students should remind you that data can be either measurements or observations.

Tell the students that now they are going to practice matching claims with supporting data. Have the students read the statements carefully because not all of the claims will make a match. Instruct them to only draw lines between the claims that match up with supporting data. Tell the students to work by themselves for the first couple of minutes (~2 minutes) and that afterwards we will go over the answers as a class.

Ask the class if anyone has identified a match and have them give you the number and the letter of the possible match. Read each suggested claim/data match and then ask the rest of the class if 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.
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 circle the changing variable (light angle), underline the controls (light color, block height, block width, light distance, and light height), and box the information about the data collected (shadow length).

Tell the students that we are now going to look over a list of statements about this results table and decide if each statement is an example of a claim or data. If the statement is data, we will box the data in the statement and if the statement is a claim, we will identify and circle the changing variable. 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 need to be carried 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 the 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 the students what data can be used to support this claim. They should respond that 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 example notebook. Ask the students how people would know that the statement generated was data. They should reply that it 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 the students if multiple claims can be made about a given set of results. The students should see that two different claims could be made from the data collected. Ask the students which claim they 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. Encourage students to think about how/why their shadows are changing lengths when they make a claim from their 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 circle the changing variables (block height and light distance), underline the controls (light color, block width, light height, and block angle), and box the information about the data collected (shadow length).

Tell the students that 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 the students why no claims can be made from the data. They should say that because 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 example notebook and have students copy this into their notebooks.

Ask the students if they think they would be able to make a conclusion when a claim cannot be made from the data. 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 the students what they learned 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 they are now going to look at three results tables and one graph and determine which data sets would allow them to make a claim/conclusion. As a class, go through each table/graph and circle the changing variable(s), underline the controls, 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 that tables (such as tables A-C) and graphs (such as graph D) represent two different ways of displaying results from an experiment. Ask the students what the advantages and disadvantages are for 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 that they will now analyze their own data to see if they can make a conclusion. Remind them that it is okay if they cannot draw a conclusion from their first experiment, because they will have the opportunity to run another experiment in which they should only have one changing variable so that they will be able to draw a conclusion.

Inform students that once they have decided if they can/cannot make a conclusion, they will either use their results to make a conclusion or state why they cannot make a conclusion from their data. Once this is complete, they can move on to designing their new experiment. Tell them that they 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, they should try to explore a changing variable that they think no one else in the class is investigating.

Tell students they will start working with their subgroup to analyze their old experiment and start their 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 when the students cannot make a conclusion is shown below on the 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 (statement that can be tested) and supporting data (measurements and/or observation) 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 when the students can make a conclusion is shown below on the right.

![Example of Conclusion](image)

**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. Each subgroup should briefly discuss how/why they think the changing variable will affect the shadow.

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 decided and circle what they will be measuring. 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 notebook 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 changing variable and controls. For the changing variable values, have students write the trial letter next to the value they select. Ask students to justify the values that they have chosen for their changing variable and controls and if these values will make it easier or harder to answer their question.

Make sure that 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 of a 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. Having the materials page filled out is essential for students to start their experiments during the next SciTrek visit. An example of an 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). 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 having problems with their procedure, they should 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 the 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 it approved by their volunteer. An example procedure can be seen below.
Tell the students that during the next SciTrek visit they will carry out the experiments that they designed today.

**Clean-Up:**

Before you leave, have students attach their nametag to their notebook and place them in the group box. Place the materials pages on top of the notebooks in your group box. Bring all materials back to UCSB. In addition, put your lab coat into your group box.

**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
- ☐ Volunteer lab coat
- ☐ (2) Pencils
- ☐ (2) Red pens
- ☐ Masking tape
- ☐ Notepad
- ☐ (3) White plastic surfaces
- ☐ Picture of Experimental Set-up

(3) Ziploc bags with the following: (labeled with subgroup number)
- ☐ Measuring tape (152 cm)
- ☐ Requested wooden blocks
- ☐ (3) Rulers
- ☐ Protractor
- ☐ White plastic surfaces
- ☐ Picture of Experimental Set-up

Other Supplies:
- ☐ Box with 9 ring stand bases, 9 flashlights, and 9 clamps with string attached
- ☐ Tube with 9 ring stand poles
- ☐ (35) Clipboards
- ☐ Bag 1: lead shadows supplies ((2) measuring tapes (152 cm), (2) flashlights without filter, (4) AAA batteries, (2) protractors, (2) clamps with string attached, (9) wooden blocks – one of each size)
- ☐ White plastic surface

Lead Box:
- ☐ (3) Extra student notebooks
- ☐ Lead instructions
- ☐ Shadows picture packet
- ☐ Lead lab coat
- ☐ Time card
- ☐ (2) Pencils
- ☐ (2) Red pens
- ☐ (2) Wet erase markers
- ☐ Notepad
- ☐ (3) Measuring tapes (152 cm)
- ☐ (6) Rulers
- ☐ (2) Masking tapes
- ☐ Picture of Experimental Set-up

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>Black Height</td>
<td>2 cm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Black Width</td>
<td>3 cm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Block Length</td>
<td>5 cm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Light Chr</td>
<td>10 cm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Light Angle</td>
<td>90°</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Light Height</td>
<td>25 cm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Avail Materials</td>
<td>Wood</td>
<td>Wood</td>
<td>Wood</td>
<td>Wood</td>
</tr>
<tr>
<td></td>
<td>Foam</td>
<td>Foam</td>
<td>Foam</td>
<td>Foam</td>
</tr>
<tr>
<td></td>
<td>Metal</td>
<td>Metal</td>
<td>Metal</td>
<td>Metal</td>
</tr>
<tr>
<td></td>
<td>Cardboard</td>
<td>Cardboard</td>
<td>Cardboard</td>
<td>Cardboard</td>
</tr>
<tr>
<td>Trial Measurements</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shadow Length</td>
<td>12 cm</td>
<td>12 cm</td>
<td>12 cm</td>
<td>12 cm</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 a shadow length of 12 cm.

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Set-Up:

SciTrek Lead:

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 pictures (page 1, picture packet). If the classroom does not have a document camera, then tape up the poster-size notebook pages on the front board.

SciTrek Volunteers:

Set out student notebooks.

- If students are not in the classroom before SciTrek starts, set out the notebooks where students should sit when they come into the classroom.
- If students are in the classroom before SciTrek starts, pass out notebooks to them; they will move to their subgroup seats after the introduction.

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.

Place subgroup bags, white plastic, and ring stands in three unique spots on the floor along with four clipboards.

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 needed, have volunteers hand out the notebooks/nametags to students in their seats. They will move into their subgroups after the introduction.

Ask the class, “What is the class question that we have been investigating?” Students should tell you, “What variables affect shadows? Tell the students that today they are going to perform their second experiment. Once the experiment is complete, they will analyze their data and determine what conclusions can be drawn from their results. Tell students that their conclusions will help answer the class question. Ask the students for the definition of a conclusion. They should respond that it is a claim supported by data. Ask the students how many changing variables experiments can have in order to make claims/conclusions. They should respond that there can only be one changing variable. Ask them why they can only have one changing variable in order to draw a conclusion. They should say that if there is more than one changing variable, they would not be able to tell which one of the multiple changing variables affects the shadow.

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 an example notebook under the document camera. Tell the students to look over the data in this results table. Ask the students what the changing variable was in the experiment. They should respond 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 the question was that these scientists were exploring. They
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 if a claim/conclusion can be made from this data. Students should realize that there is only one changing variable, so a claim/conclusion can be made from these results.

Tell the class that now that they know a conclusion can be made from the data, they are going to work together to come up with a conclusion. Explain that 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?” 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 that 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 they try to generate a claim about their data, they should try to have a claim that would allow them to make a prediction. Write the claim in the example notebook and have students copy it into theirs.

Ask the 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 they know that the statement generated was data. Students should say that 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 example 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. Show students the example block. Place the block on the edge of the picture pack and tell them that the picture pack will represent the white plastic and the light source would be in front of the block. Ask the students what we call the block dimension going up. They should respond height. Ask the students what we call the block dimension going across the front of the white plastic. They should respond width. Ask the students what we call the block dimension going away from the light. They should respond length. Show students that if they forget the dimensions they can look at the picture at the top of their results table.

Put page 1 of the picture pack 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, explain to the students that when measuring the length of the shadow they will line up the 0 cm mark of a ruler with the front of the block (front of the white plastic). They 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 explain when measuring the shadow width, they will place two rulers (numbers side down) perpendicular to the short side of the white plastic on either side of the shadow. They will then measure between the two rulers with a third ruler to find the shadow width resulting in the rulers making an “H.”

Remind students that they must have their procedure and results table completed before they can start their experiment. If needed, tell students to get together with their group and start working.

**Procedure:**

(5 minutes – Subgroups – SciTrek Volunteers)

Help subgroups complete their procedures (page 19). 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 having problems with their procedure they should 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 the group box. Give this sheet to the students to copy into their notebooks. Once the students have their procedure written in their notebooks they should raise their hands and get their procedure approved by their SciTrek volunteer. An example procedure can be seen below on the left.

**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 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; for the changing variable, they write the value in each of the boxes.

When students have finished, have them make predictions about the shadow lengths/widths. Have them write a “B” in the box of the trial they think will produce the biggest shadow length/width and an “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 be the same length/width, have them write “same” over all of the boxes. Try to question each subgroup on their thought process behind their predicted lengths/widths. An example results table can be seen above on the right.
Experiment:
(25 minutes – Subgroups – SciTrek Volunteers)

When students are ready to start their experiment they may go to where their supplies are on the floor. 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 to tape down their measuring tape so that it does not move. For these students, the measuring tape should go under the protractor. For groups 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. In addition, verify that 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 the students’ set-up, verify that they have their block in the correct orientation. If the students chose to change the light angle and the shadow is too wide for 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, use a measuring tape found in the lead box.

Make sure that the students are measuring the correct shadow dimension (length or width) stated in their question and that the shadow is being measured as described in the Set-Up 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 they 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 of a properly filled out results table is shown below in the Graph section on the left.

Graph:
(5 minutes – Subgroups – SciTrek Volunteers)

Help students fill out their graph by having them go through and complete the checklist on page 22. Be sure that students label the y-axis with the dimension they measured, either 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 this example, the trials were graphed in the following order: E, H, G, F. Once they have graphed their values, make sure that 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 of a properly filled out graph is shown below on the right.
Conclusion:

(8 minutes – Subgroups – SciTrek Volunteers)

Have students use their graph to look for a pattern in their data. This will help them summarize their findings. Challenge students to think about how their changing variable did or did not affect the shadows' length/width.

When writing their conclusion, make sure that students start the statement with a claim (a statement that can be tested) about the trend or pattern in their data. They will then write “because” and use data to back up the claim. The data in this experiment is usually in the form of measurements. Make sure students are using their changing variable values (not trial letters) and specific measurements to support their claim.

If the values of their changing variable have an order (example: 2 cm → 5 cm → 8 cm → 10 cm), then that variable affected the shadow length/width. If, on the other hand, there was no order for their changing variable values (example: 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 a prediction about something that they have not tested. Challenge students to think about how (claim 1 and 2 below) the 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).

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 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.

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**CONCLUSION**

We can conclude that increasing 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 was 9 cm.

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**Wrap-Up:**

(2 minutes – Subgroups – SciTrek Lead)

Tell the students that during SciTrek’s next visit they will have time to finish their conclusions and then make a poster to share their results with the class.

**Clean-Up:**

Before you leave, have students attach their nametag to their notebook and place them in the group box. Bring all materials back to UCSB. In addition, put your lab coat into your group box.
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 ☐ (2) Pencils ☐ (3) Poster parts packs
☐ Student notebooks ☐ Notepad (scientists’ names, question,
☐ Volunteer instructions experimental set-up, procedure,
☐ Volunteer lab coat results table, results graph,
☐ Poster diagram conclusion, (4) “I acted like a
☐ (3) Stickers on how to present scientist when”, (4) picture
graph spaces)

Other Supplies:

☐ Poster paper tube

Lead Box:

☐ (3) Extra student notebooks ☐ (3) Stickers on how to present
☐ Lead instructions graph
☐ Shadows picture packet ☐ (2) Pencils
☐ Poster diagram ☐ (2) Wet erase markers
☐ Lead lab coat ☐ Notepad
☐ Time card ☐ (9) Paperclips

Set-Up:

SciTrek Lead:
Ask the classroom teacher for a place to leave the student posters in the classroom.

SciTrek Volunteers:
Set out student notebooks.

- If students are not in the classroom before SciTrek starts, set out the notebooks where
  students should sit when they come into the classroom.
- If students are in the classroom before SciTrek starts, set out the notebooks where
  students should sit during the module; they will move to these spots after the
  introduction.

Have poster parts ready for students.
Introduction:
(2 minutes – Full Class – SciTrek Lead)

If needed, while you are doing the introduction have volunteers set out the notebooks/nametags where they would like students to sit. Make sure that students in the same subgroup are sitting next to each other. Tell students that a notebook will be put on their desk, which is not their notebook and they should not move it.

Ask the class, “What is the class question that we have been investigating?” Students should tell you, “What variables affect shadows?” Inform the class that they will be making posters to present their findings to the class. Before they make posters, they will have to finish their conclusions. Ask the class how scientists define a conclusion (a claim supported by data). Ask the class what a claim is (the explanation of your results, a statement that can be tested) as well as what can be used for data (measurements or observations).

After they finish their conclusion, they will fill in the sentence frame “I acted like a scientist when” stating how they acted like a scientist during their SciTrek experience. Challenge students to come up with a unique answer that no one else in their subgroup wrote.

Tell students they when scientists complete their experiment, they make a poster to present their work to other scientist; therefore, each subgroup will create a poster to present to the class during the next SciTrek visit. They will get to pick which one of their two experiments to present, but it should be an experiment in which they were able to draw a conclusion. This presentation will be their chance to tell the class what their subgroup has discovered about the class question. Tell students that they should write as neatly as possible on the poster parts so that the other class members can read their poster.
Tell students they will now start working with their subgroup to analyze their experimental results and then make a poster.

**Conclusion:**
(*18 minutes – Subgroups – SciTrek Volunteers*)

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 students have determined their claim, have them determine the supporting data. Have students look at their results table/graph and write in words what measurements or observations were used to support their claim. In most cases, you can have students select the two data points that best support their claim. This is usually the largest and the smallest measurements.

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

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.

Example student work for the conclusion section can be seen 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 they did during each SciTrek visit.

**Poster Making:**

*(35 minutes – Subgroups – SciTrek Volunteers)*

Each subgroup (three/four students) will make one poster on 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 help better 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 (not presented)</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 (not presented)</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 all writing sections are completed, have students 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” 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 to flip back and forth between pages.

Place the following sentence frame sticker on the bottom of the notebook page of the student that is completing the results graph (page 22, student notebook).

<table>
<thead>
<tr>
<th>Changing variable</th>
<th>value</th>
<th>measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Changing variable</td>
<td>value</td>
<td>measurement</td>
</tr>
</tbody>
</table>

Then practice reading the four sentences with that student. For the poster below, the first sentence would be: When the block length was 3 cm the shadow length was 7 cm. Make sure you fill in the first and third blanks (example: block length and length) in the sentence frame for the student in the sentence frame but leave the second and fourth blanks (‘value’ and ‘measurement’) empty.
As soon as students have completed some of their pieces, start gluing them onto the large poster paper 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 that students read from their notebooks instead of off 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 values of their changing variable 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 that the other students will ask them questions during their poster presentations. Tell them that they should think about what questions they will be asked and then think of the answers to those questions so that they will be prepared during their presentation.

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

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

After having a discussion about how they acted like scientists and talking about how everyone does things that scientists do in their everyday lives, tell students that they will present their findings during the next SciTrek visit and that you are looking forward to hearing about all of their experiments.
Clean-Up:

Before you leave, have students attach their nametag to their notebook and place them in the group box. Leave student posters in the classroom. Bring all materials back to UCSB. In addition, put your lab coat into your group box.

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

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

*Student posters should already be in the classroom.

Set-Up:

SciTrek Lead:

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.

Organize the posters so that groups that had the same changing variable present back to back.

SciTrek Volunteers:

Set out the notebooks/nametags. Today students will be sitting in their regular classroom seats during poster presentations. Have pencils ready to distribute to your group after the 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 that today they will present their posters to the class. Inform students that 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 the students that they will have 5 minutes to practice presenting their poster with their subgroup. Remind students to read from their notebooks when presenting. Tell students that after practicing, they will return to their normal classroom seats.

**Practice Posters:**
(5 minutes – Subgroups – SciTrek Volunteers)

If the posters are not already in order, the lead should organize the posters so the experiments featuring the same changing variable are presented back to back.

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 that we have been working on solving?” Students should tell you, “What variables affect shadows?” Tell students that during the presentations they are going to take notes. Have them turn to page 24 in their notebook while you turn to page 5 of the picture packet. Tell them that they need to record each subgroup’s changing variable and what data they will be collecting after the subgroup says their question. In addition, they will record the values of the changing variable and the measurements when the subgroup presents their graph.

After each presentation, students will be given the opportunity to ask scientific questions to the presenting subgroup to help them determine if/how the variable investigated affected the shadow. Tell them these questions are important because they will have to record a summary of what they learned from the subgroup. Therefore, their questions should focus on helping them be able to summarize the subgroup’s findings. Tell them that if they ask a scientific question during the presentation, they 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 SciTrek 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).

Below is an example of notes that the lead/students could have taken during the poster presentations.
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 distance increases, the shadow length increases but the shadow width stays the same
- As the light height increases, the shadow length and width decreases
- 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. Tell students you want to get the longest shadow and that you need them to tell you what values of variables you should use.

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

Tell students you want to get the widest shadow and that you need them to tell you what values of variables you should use.

- Block Height: Any height
- Block Width: As wide as possible
- Block Length: Any width
- Light distance: Any distance
- Light Height: As low as possible
- 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, so do not expect them to tell you which value to use. Tell students they have taught you a lot about shadows.

**Wrap-Up:**

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

Tell the students that the volunteers that have been working with them are undergraduate and graduate students that volunteer their time so that they can do experiments. Have the students say thank you to the volunteers. This is the last day with their SciTrek volunteers, therefore, they should say goodbye to them. Tell students that you will be back one more time.

Tell students to remove the paper part of their nametag from the plastic holder and that they can keep the paper nametag, but they need to give the plastic holder back to their SciTrek 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:**

Before you leave, collect the plastic nametag holders and put them in the group box. Students can keep the paper part of their nametag. Collect notebooks and place them in the group box. Leave student posters in the classroom. Bring all materials back to UCSB. In addition, if you will not be attending the Tie to Standards day, remove all materials from lab coat pockets, remove your nametag, unroll 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 a circle 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: Shorter
  - Shadow Width: Narrower

Experiment 2: Effects of Changing Light Height
- What will happen to:
  - Shadow Length: Longer
  - Shadow Width: Wider

Experiment 3: Effects of Changing Light Distance
- What will happen to:
  - Shadow Length: Shorter
  - Shadow Width: Narrower

Experiment 4: Effects of Changing Light Angle
- What will happen to:
  - Shadow Length: Longer
  - Shadow Width: Wider

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? Sunrise 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 winter. 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 and in the winter there were 10 hours of daylight.

11. Using the sun dials 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
**Set-Up:**

SciTrek Lead:

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 Tie to Standards pictures (pages 6-11, picture packet). If the classroom does not have a document camera, then tape the example poster-size notebook pages to the front board.

If the teacher is not leading the Tie to Standards activity, give them an extra student notebook and have them fill it out with their students to follow along.

Pass out notebooks to students. If you do not have time to get set up before the start of the module, ask the teacher to pass out notebooks.

Remind the teacher to give you their lab coat 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. One of the ways that we get program funding is by demonstrating the program effectiveness. Therefore, we need you to do your best on the assessment.” Pass out the conclusion assessment and tell students to fill out their name, teacher’s name, and date on the top of the assessment. Remind the students that it is important that they fill out this assessment on their own.

For page 1, read the instructions to the students. Then read each of the statements and tell the students to circle if the statement is a claim, data, or opinion. As you are reading the statements walk around the room and verify that students have written their name on the top of the paper.

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 one of the instructions to the students (identify the following statements as either CLAIM or DATA and write a C or D on the line). Then have students fill in if they think statement “a” is a claim or data by writing a C or D on the line. Tell students this is similar to page 1 of the assessment. Read step two of the instructions to the 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 they have completed statement “a” move on to the next statement. Read each statement aloud and tell students to write the appropriate letter on the line then circle if the statement is a correct claim, correct data, or incorrect.

Repeat the process for page 3. Read the question on the bottom of page 3 to students and have them fill in the blank. When they are finished, collect the assessments and verify that the students’ names are on the top of the papers.
Tie to Standards:
(50 minutes – Full Class – SciTrek Lead)

Effects of Changing the Light (15 minutes)

Tell the students that today they are going to talk about their previous experiments and hopefully answer any questions that they may still have about what variables affect shadows. Have the students turn to page 26 in their notebooks. Tell the students that 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.

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°. Tell the students to circle if they think the shadow length will be shorter, stay the same, or be longer and if they think the shadow width will be thinner, stay the same, or be wider when the light color is changed from orange to blue. 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 changed what happened to the shadow length and width? Tell students not to erase their predictions but to put a box around the correct answers. On the example notebook box “same” for shadow length and shadow width.

Tell students that 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. Have students circle what they think will happen to the shadow length and width when the light height is increased from 20 cm to 60 cm. 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 not to erase their predictions but to put a box around the correct answers. On the example notebook, box “shorter” for shadow length and “thinner” for shadow width.

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°. Have students circle what they think will happen to the shadow length and width when the light distance is changed from 10 cm to 60 cm. 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 the 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 student not to erase their predictions but to put a box around the correct answers. On the example 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.

![Experiment 3: Effects of Changing Light Distance](image)

![Experiment 4: Effects of Changing Light Angle](image)

Tell students that 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. Have students circle what they think will happen to the shadow length and width when the light angle is changed from 90° to 150°. 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 the 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 that the shadow will always be in line with (or 180° from) the light source. Tell students not to erase their predictions but to put a box around the correct answers. On the example notebook, box “shorter” for shadow length and “wider” for shadow width.
Connection to the Sun (10 minutes)

Tell students now that they understand how to predict what shadows will look like, they will connect these predictions to other uses. Have the 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 that 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 that 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) the sun rises in and which it sets in and 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 that 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.

Now that students understand where the sun rises and sets as well as what a shadow will look like for a corresponding light source, they 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 example 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.

After completing the picture, ask students at what time of day shadows are longest and when they are shortest. Students should see that at sunrise and sunset, when the sun is low, the shadows are the longest and that at noon, when the sun is directly above objects, the shadows are the shortest. Next, ask students how we know this. They should respond that 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.

Seasonal Shadows (23 minutes)

Pass out a red pen to each student.

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

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

1. Why are the data points all zero between midnight and 4 am? (it was night so there was no shadow)
2. 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)
3. 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)
4. 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)
5. How many hours passed between the time that the sun rose and the time the sun was directly overhead? (5 hours)
6. How much time passed between the time the sun was directly overhead and the time the sun set? (5 hours)
7. Is the graph symmetric? (yes)
8. How many hours of daylight are there during the winter? (10 hours)
How Shadow Length Varies in the Winter

<table>
<thead>
<tr>
<th>Time</th>
<th>Shadow Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>12:00 am</td>
<td>0</td>
</tr>
<tr>
<td>2:00 am</td>
<td>0</td>
</tr>
<tr>
<td>4:00 am</td>
<td>0</td>
</tr>
<tr>
<td>6:00 am</td>
<td>0</td>
</tr>
<tr>
<td>7:00 am</td>
<td>5</td>
</tr>
<tr>
<td>8:00 am</td>
<td>2</td>
</tr>
<tr>
<td>10:00 am</td>
<td>0.5</td>
</tr>
<tr>
<td>12:00 pm</td>
<td>0</td>
</tr>
<tr>
<td>2:00 pm</td>
<td>0.5</td>
</tr>
<tr>
<td>4:00 pm</td>
<td>2</td>
</tr>
<tr>
<td>5:00 pm</td>
<td>5</td>
</tr>
<tr>
<td>6:00 pm</td>
<td>0</td>
</tr>
<tr>
<td>8:00 pm</td>
<td>0</td>
</tr>
<tr>
<td>10:00 pm</td>
<td>0</td>
</tr>
<tr>
<td>12:00pm</td>
<td>0</td>
</tr>
</tbody>
</table>

Ask students if a graph of shadow length vs. time would be the same for all times of the year (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 that they will now graph the actual data showing shadow length vs. time during the summer using their pencil. Show students the data table while reading it to them (page 11, picture packet, shown below on then left). In addition, plot the data points in the example 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)
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 they can make from the graphs 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 group notebook and have students copy it into their notebook. Ask the class what part of the conclusion was the claim and how they know this. They should reply “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 they know this. They should reply that “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. If students are having trouble go back to the graphs and count the number of daylight hours in both graph with the students.

Sundials (2 minutes)

Tell students that 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. Tell students to use the three sundials in their 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 the students that they have taught you a lot about shadows. You now know that the larger the light distance and the smaller the light height, the longer the shadow. In addition, you saw that the shadow is always 180° from the light source. Knowing these facts about shadows has allowed you to see how shadows can be used to tell time.

Tell students that they can keep their notebooks and that you have enjoyed learning science with them, and they will get another opportunity for SciTrek to come to their class and run another long term investigation with them later in the year. Tell them to remember what they have learned from this module for their next module.

Clean-Up:

Collect the teacher’s lab coat and bring all materials back to UCSB.
Extra Practice Solutions:

EXTRA PRACTICE

Conclusions

Directions:
On the results table, circle each changing variable, underline each control, and box information about data collectors.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Trial A</th>
<th>Trial B</th>
</tr>
</thead>
<tbody>
<tr>
<td>light color</td>
<td>White</td>
<td></td>
</tr>
<tr>
<td>block height</td>
<td>5 cm</td>
<td>10 cm</td>
</tr>
<tr>
<td>block width</td>
<td>7 cm</td>
<td></td>
</tr>
<tr>
<td>light clearance</td>
<td>25 cm</td>
<td></td>
</tr>
<tr>
<td>light height</td>
<td>25 cm</td>
<td></td>
</tr>
<tr>
<td>light distance</td>
<td>45 cm</td>
<td></td>
</tr>
</tbody>
</table>

Data

<table>
<thead>
<tr>
<th>Observations/Measurements</th>
<th>Shadows Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trial A</td>
<td>7 cm</td>
</tr>
<tr>
<td>Trial B</td>
<td>15 cm</td>
</tr>
</tbody>
</table>

Can this group make a claim/conclusion? No

Step 1: Statement Type C or D

1. The block height affects the shadow length.
   - Correct Claim  Correct Date  Incorrect
2. The block height does not affect the shadow length.
   - Incorrect  Correct Claim  Correct Date
3. When the light height is 25 cm, the block height results in a longer shadow.
   - Incorrect  Correct Claim  Correct Date
4. The light distance affects the shadow length.
   - Incorrect  Correct Claim  Correct Date
5. The light distance affects the shadow length.
   - Incorrect  Correct Claim  Correct Date

What data can be used to support the correct claim(s) above?

When the block height was 5 cm, the shadow length was 7 cm, and when the block height was 10 cm, the shadow length was 15 cm.