Module 2: Chromatography
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: Conclusion Assessment/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: Draw a Scientist/Tie to Standards/Content Assessment (60 minutes)

*This schedule assumes the teacher has given the conclusion assessment before SciTrek comes on Day 8 of the module.

The exact module dates and times are posted on the SciTrek website (http://www.chem.ucsb.edu/scitrek/elementary) under the school/teacher. The times on the website include transportation time to and from the SciTrek office (Chem 1105). Thirty minutes are allotted for transportation before and after the module, therefore, if a module was running from 10-11 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-PS1-3  Make observations and measurements to identify materials based on their properties.
Learning Objectives:

1. Students will be able to list at least one physical property of a substance.
2. Students will know that mixtures can be separated based on the physical properties of individual substances in the mixture.
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 final conclusion assessment prior to Day 8 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 the students’ desks/tables moved into three groups and cleared off. This ensures that each student has a desk during SciTrek activities and that students can begin the module as soon as SciTrek arrives.

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 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). This will allow the SciTrek staff to provide you with all needed materials.

Day 1:
If you would like to have more time for your students to make observations and generate variables, you can do the conclusion assessment before SciTrek arrives.

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 (highly recommend).

Materials Used for this Module:

1. Crayons Crayola 8 count
2. Test tubes 25 x 150 mm (VWR Part Number: 47729-586)
3. Corks (Size 10) (Fisher Part Number: 07-781N)
4. Test tube stands (hand made by cutting a 2x4 into 15.5 cm long pieces and drilling four holes with a 1 in drill bit 2.5 cm deep along the center line of the block)
5. Nalgene graduated cylinders 10 ml (Fisher Part Number: 08-572-5A)
6. Chromatography paper (roll 2 cm x 100 m (thickness 0.18mm) cut into 11.5 cm strips) (Fisher Part Number: S47087)
7. Other papers (all papers are cut into 2 cm x 11.5 cm strips)
   - Papers (coffee filter, construction paper, graph paper, newspaper, paper towel, and copy paper)
8. Rulers (Office Depot Part Number: 21215472)
9. MyChron Timers (Fisher Part Number: S65330)
10. Disposable pipets (droppers) (Fisher Part Number: 13-711-7M)
11. Markers
   - Mr. Sketch (red, orange, yellow light green, dark green, light blue, dark blue, purple, light pink, dark pink, black, and brown)
   - Crayola (red, yellow, green, blue, purple, black, and brown)
   - Expo-Overhead pens (red, yellow, green, blue, purple, black, and brown)
   - Sharpie (red, yellow, green, blue, purple, black, and brown)
   - Rose Art (red, yellow, green, blue, purple, black, and brown)
   - Other Black Pens (Bic, Dry Erase, and Paper Mate)
12. Water
13. Rubbing alcohol (RA)
14. White vinegar
15. Dish soap (without dilution, the dish soap is too thick to be absorbed by the paper, therefore, a soap solution is made by mixing equal parts of water and dish soap)
16. 1 oz. Plastic cups (Smart and Final) labeled: water, RA, soap, and vinegar
17. Bags with 2 oz. of the following: baking soda, corn starch, salt, and sugar (both labeled with their names and A, B, C, and D) (Uline Part Number: S485)
18. Bottle containing sand and water

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: Conclusion Assessment/Observations/Variables

Schedule:

Introduction (SciTrek Lead) – 2 minutes
Conclusion Assessment (SciTrek Lead) – 10 minutes
Observation Discussion (SciTrek Lead) – 2 minutes
Observations (SciTrek Volunteers) – 26 minutes
Variable Discussion (SciTrek Lead) – 5 minutes
Variables (SciTrek Volunteers) – 12 minutes
Wrap-Up (SciTrek Lead) – 3 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

□ Ziploc bag
□ (2) Rulers
□ Paper towels
□ Timer
□ Water (8 oz.)
□ Dropper
□ Test tube with cork
□ Test tube stand
□ 10 mL Graduated cylinder
□ (2) Pieces of chromatography paper with pencil line drawn 2 cm above bottom
□ Black marker (Mr. Sketch)
□ (5) Boxes of crayons (8 colors only)

Other Supplies:

□ (3) Large group notepads
□ (3) Trays
Lead Box:
☐ (3) Blank nametags
☐ (3) Extra student notebooks
☐ Lead instructions
☐ Chromatography 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)
☐ (2) Ziploc bags
☐ (2) Rulers
☐ Paper towels
☐ (2) Timers
☐ Water (8 oz.)
☐ (2) Droppers
☐ (2) Test tubes with corks
☐ (2) Test tube stands
☐ (2) 10 mL Graduated cylinders
☐ (4) Pieces of chromatography paper with pencil line drawn 2 cm above bottom
☐ (2) Black markers (Mr. Sketch)
☐ (5) Boxes of crayons (8 colors only)

Notebook Pages and Notepad Pages:

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OBSERVATIONS

Experimental Set-Up:
- Graduated cylinder with 2 mL of water
- Paper 11.5 cm high with line on it at 2 cm
- Black Mr. Sketch pen
- Timer
- 5 boxes of crayons
- Test tube and test tube holder

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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). If the classroom does not have a document camera, then write the class question on the board during the variable discussion.

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

As students are taking the conclusion assessment, walk around the room and quietly place the students’ nametags, which are in your group box, on each student’s desk.

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 tray. Use the following steps to help you with the set-up:
1. Fill a 10 mL graduated cylinder with 2 mL of water and place on tray.
2. Place the test tube (with cork) in the test tube stand and place on tray.
3. Set the piece of chromatography paper (with the pencil line drawn at 2 cm from the bottom of the paper), test tube and holder, graduated cylinder with 2 mL of water, black Mr. Sketch marker, paper towel, timer, ruler, and 5 boxes of crayons on the tray.
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 – SciTrek Lead)

As students are taking the assessment, the volunteers should get the students’ nametags out of their group boxes and walk around the room locating quietly setting each student’s nametag on their desk. After volunteers have handed out the nametags, they should assemble the experimental set-up.

“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, 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 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.

Observation Discussion:
(2 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 strip of paper at three different times. The first time will be before we put the paper in the test tube with water and the other two times will be after the paper is put in the test tube with water.” Remind them to make both written and illustrated observations in their notebooks.

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.

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:
(26 minutes – Groups – SciTrek Volunteers)

Once the students come over to your group, have them sit in boy/girl fashion. Verify the tray is set up as described in the Set-Up section. 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 on the front cover of their notebooks. Students will leave the subgroup number and class question blank. Then have students turn to page 2 of their notebook.

As a group, have the students generate ~six observations about the experimental set-up. Observations should be recorded in the group notepad under “Experimental Set-Up” and then copied by student into their notebooks. Observations about the experimental set-up should be recorded in bullet points to save time. Verify that students know the container holding the liquid is called a graduated cylinder, and it is used to measure liquid amounts. Make sure to record the following observations about the experimental set-up: liquid amount (2 ml), paper height (11.5 cm), line height on paper (2 cm). Encourage students to make other observations (~1 minute) that are not on the group notepad and write them in their notebooks. This should take you no longer than 6 minutes. See example notebook below for possible experimental set-up observations; feel free to deviate from the example.

With the black Mr. Sketch marker, make a dot in the middle of the line on the paper (the smaller the dot, the better the results). Have students look at the paper and tell them to remember what it looks like because this will be their “time 0” observation. Pour the 2 mL of water into the test tube, place the paper into the test tube, cork the system, and start the timer. It is important that this is done prior to having
students record their time 0 observations so that enough time passes (~ 3 minutes) between time 0 and time 1. Record 0 seconds under the time because this is when the strip of paper was put into the test tube. Then have students draw a picture of their observations of the paper at time 0 using the black crayon. In addition, have students generate written observations/measurements and record these under the time 0 section of the chart on the group notepad and have the students copy this information into their notebook.

After students have completed their time 0 observations, record the time on the timer. This will be time 1 (~3 minutes). DO NOT STOP THE TIMER OR TAKE THE STRIP OUT OF THE TEST TUBE AT TIME 1. Have the students draw a picture of what the paper looks like at time 1 using the crayons on the tray. Make sure students draw their picture to match the strip of paper in front of them. A common mistake that students make is drawing the dye colors going up from the bottom of the paper instead of up from the line. After their pictures are complete, make written observations as a group about time 1 and record these on the group notepad and have the students copy this information into their notebooks.

After students have completed their time 1 observations, remove the paper and place it on a paper towel on the table. At the same time, stop the timer. Record this time (~7 minutes) for time 2 on the group notepad. Ask the students, “What do you see now that will disappear by tomorrow?” They should respond with, “the water line.” Tell the students that in order to know the location of the water, we use a pencil to trace the water level. Have the students draw a picture of the strip, including the water line, for time 2. Then as a group, have the students come up with written observations and record these on the group notepad. Make sure that in the time 2 observations/measurements section of the chart, students record the height of the smear and the height of the liquid. Have the students copy these observations from the group notepad into their SciTrek notebooks.

If there is extra time, have the students write a summary of what happened during the experiment. 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 how the dot changed over time. Make sure that by the end of the discussion, students have identified that there was originally a black dot on the line. When the paper was placed in water, the water moved up the paper, the dot separated into several colors, and as more time passed, the separation became larger.

Ask the class what the most interesting observation was. They should reply that the black dot spread out into multiple colors. Tell the class that we will call this a smear, and we will now work together to answer the question, “What variables affect smears?” Write this question on the front page of the example notebook under the document camera and have students copy it onto their notebooks.

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)
- Do you think that there are multiple variables that will affect the smears? (multiple variables might affect the smears)
- Explain that this is why we will need to work as a class to answer the class question: “What variables affect smears?”

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 smear; 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 smear. 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: paper type  
Why might this variable affect the smear? Different papers might absorb different amounts of liquid.  
How would you test this variable? Get different types of paper and put black dots on them and put them in water.  
Prediction: The more absorbent the paper, the larger the smear would be.

Tell students they will now generate more variables and analyze them in their groups.

Variables:  
(12 minutes – Groups – SciTrek Volunteers)

As a group, generate a variable and make a prediction about how it will affect the smear. Encourage and challenge students to explain why they think their prediction is correct and how this variable will affect the smear. 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 smear, and record their ideas in their notebooks. Have students share these ideas with the group.

Prepare one student to share a variable and why they think it will affect the smear during the class discussion.
Wrap-Up:
(3 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 smear. Make sure that students tell you their predictions about how different values of that variable will affect the smear.

Tell the students that the next time we meet they will design an experiment to answer the question (What variables affect smears?).

Clean-Up:

Before you leave, have students attach their nametag to their notebook and place them in the group box. Put the test tube, liquid in test tube, and graduated cylinder in Ziploc bag and seal. Do not leave the cork in the test tube or put it in the Ziploc bag. Put all of the materials into your group box. 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
- ☐ Chromatography picture packet
- ☐ Lead lab coat
- ☐ (3) Materials pages
- ☐ (2) Pencils
- ☐ (2) Red pens
- ☐ (2) Wet erase markers
- ☐ (3) Markers (orange, green, blue)
- ☐ Notepad

Notebook Pages:

Experimental Considerations:
1. You will only have access to the materials on the materials page.
2. The stripe of paper cannot be in the liquid for more than 1 minute.
3. All strips of paper must be put into the liquid at the same time.

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 our group why you think that variable will affect the smear.

Changing Variable 1:
Discuss with your group how you think changing variable 1 will affect the smear.

Changing Variable 2 (optional):
Discuss with your group how you think changing variable 1 will affect the smear.

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

Justify your Group's Choice:
- Paper Type: __________
- Paper Color: __________
- Paper Thickness: __________

What will happen to the Height and Color of the Smear

Experimental Set-Up:
Determine the values of your changing variable(s) (ex: pen color) from the materials page and write the values (ex: blue) for your four trials under each strip of paper.

Changing Variable(s):
1) Pen Type: __________
2) Liquid Type: __________
3) Dot Height: __________

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

Container: __________
Time: __________
Liquid Amount: __________

SciTrek Member Approval: __________
Set-Up:

SciTrek Lead:

If the classroom has a document camera, ask the teacher to use it for the question (page 4, student notebook), materials page (lead box), experimental set-up (page 5, student notebook), and example Day 1 strip (page 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 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 4, 5 and 6).

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, and show them the picture of the example strip (page 1, picture packet) to help remind them. They should reply that they put a black dot on a piece of paper and observed that the dot separated into different colors when the paper absorbed water. They also generated variables that might affect the smear. Ask the class if they remember the class question they will investigate. They should reply, “What variables affect smears?”

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 the smear. 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. The strips of paper cannot be in the liquid for more than 5 minutes.
3. All strips of paper must be put into the liquid at the same time.

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 liquid amount and pen color; then write down the changing variables on the example notebook (page 4) 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).

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 liquid amount and pen color, what will happen to the height and color of the smear? 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.
Tell them once they have determined their question and have approval, their SciTrek volunteer will give them a materials page for determining the values of their changing variable(s) and controls. Ask students if they know how scientists define controls. Make sure that by the end of the conversation students understand that controls are variables that are held constant during an experiment. For example, if the pen type was Mr. Sketch for all of the trials, then one of their controls would be pen type. These controls and control values can be different from the original experiment that they conducted on Day 1, but must remain constant throughout all the trials that they do for this experiment.

Show students the 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: “water” for “liquid type”). Make sure to following all restrictions listed (example: liquid amount may only be 0 ml – 20 ml). 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 liquid amounts and they picked 10 ml, 11 ml, 12 ml, and 13 ml, 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 student who chose to help when filling out the experimental set-up.
Tell students that once they have completed their materials page, they will fill out their experimental set-up (page 5, 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: liquid amount) and the value of that control on the right side of the slash (example: 2 ml). There are seven possible variables to choose from on the materials page. If a subgroup changes three variables, they will be left with one control blank 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 an additional variable that does not come from the materials page. Lead students to realize this should be cork placement/on.

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. Above 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 that after 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 6 of their notebook (Put colored dot with Mr. Sketch pens A) red, B) blue, C) green, and D) yellow on original paper at 2 cm.). 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 smear.

After subgroups have decided on their changing variable(s), have them fill out their question. When you sign off on their question, give them a materials page with their subgroup color and number designated in the upper right-hand corner. An example 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 liquid amounts, dot heights, and times that are within the limitations given on the materials page. An example filled out materials page is shown in the experimental set-up section below (left).
**Experimental Set-Up:**
*(8 minutes – Subgroups – SciTrek Volunteers)*

Have subgroups use their materials page to fill in their experimental set-ups on page 5 of their notebooks. For subgroups that have three changing variables, there will be one control blank that will not come from the materials page, students should put cork placement/on. When you sign off on their experimental set-up, collect the materials page and verify that it is filled out correctly and completely. 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 (right).

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**Materials Page**

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**Procedure:**
*(19 minutes – Subgroups – SciTrek Volunteers)*

After each subgroup has filled out their experimental set-up, they can start on their procedure (page 6, 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 pen color as a changing variable would be: “Put colored dot with Mr. Sketch A) red, B) blue, C) green, and D) yellow on original paper at 2 cm.” 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 smears?

**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) – 17 minutes
- Graph (SciTrek Volunteers) – 10 minutes
- Conclusion Activity (SciTrek Lead) – 20 minutes
- Wrap-Up (SciTrek Lead) – 2 minutes
Materials:

(3) Volunteer Boxes:
☐ Student nametags ☐ Notepad ☐ (12) Small cups (labeled with liquid types)
☐ Student notebooks ☐ (6) Rulers ☐ Vinegar
☐ Volunteer instructions ☐ Paper towels ☐ Soap
☐ Volunteer lab coat ☐ Water ☐ Rubbing alcohol
☐ (3) Pencils ☐ (3) Test tube stands
☐ (2) Red pens
☐ (3) Ziploc bags labeled with the following: (labeled with subgroup number)
☐ (2) 10 mL Graduated cylinders ☐ Requested strips of paper ☐ Timer
☐ (4) Corks ☐ Requested pens ☐ Filled out materials page
☐ (2) Droppers ☐ Paper towel

Other Supplies:
☐ Box of test tubes ☐ Bucket with lid

Lead Box:
☐ (3) Extra student notebooks ☐ Notepad ☐ Bag 1: lead chromatography supplies ((4) 10 mL graduated cylinders, (10) corks, (8) droppers, (12) small cups (labeled with liquid types), paper towels)
☐ Lead instructions ☐ (6) Rulers ☐ Bag 2: lead chromatography supplies (chromatography paper (minimum 30), 6 paper types (minimum 20 each), 8 different black pens, 5 sets of different colored markers)
☐ Chromatography picture packet ☐ (2) Timers ☐
☐ Lead lab coat ☐ Water ☐
☐ Time card ☐ (2) Test tube stands
☐ (2) Pencils ☐ Vinegar
☐ (2) Red pens ☐ Soap
☐ (2) Wet erase markers ☐ Rubbing alcohol
Notebook Pages:

### RESULTS

**Table**

<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>Container</td>
<td>Test Tube</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time</td>
<td>6 min</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liquid Type</td>
<td>RA</td>
<td>Vinegar</td>
<td>water</td>
<td>soap</td>
</tr>
<tr>
<td>Liquid Amount</td>
<td>5 mL</td>
<td>2 mL</td>
<td>3 mL</td>
<td>1 mL</td>
</tr>
<tr>
<td>Paper Type</td>
<td>original</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pen Color</td>
<td>black</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initial Dot Height</td>
<td>Mr. Sketch</td>
<td>Expo</td>
<td>BiC</td>
<td>Dry Erase</td>
</tr>
<tr>
<td>Ink Color</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Predictions**

- For Trial A, if the liquid is not mixed well, the dot will be broken down more in the dry erase marker.
- For Trial B, if the liquid is not mixed well, the dot will be broken down in the Expo marker.
- For Trial C, if the liquid is not mixed well, the dot will be broken down in the BiC marker.
- For Trial D, if the liquid is not mixed well, the dot will be broken down in the Mr. Sketch marker.

<table>
<thead>
<tr>
<th>Data</th>
<th>Trial A</th>
<th>Trial B</th>
<th>Trial C</th>
<th>Trial D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>10 min</td>
<td>15 min</td>
<td>20 min</td>
<td>25 min</td>
</tr>
<tr>
<td>Initial Dot Height</td>
<td>1 cm</td>
<td>2 cm</td>
<td>3 cm</td>
<td>4 cm</td>
</tr>
<tr>
<td>Final Observations</td>
<td>8 cm</td>
<td>7.5 cm</td>
<td>7 cm</td>
<td>6.5 cm</td>
</tr>
<tr>
<td>Measurements</td>
<td>4 mL</td>
<td>5 mL</td>
<td>3 mL</td>
<td>2 mL</td>
</tr>
<tr>
<td>Liquid Type</td>
<td>yellow</td>
<td>black</td>
<td>red</td>
<td>blue</td>
</tr>
<tr>
<td>Pen Type</td>
<td>Mr. Sketch</td>
<td>Expo</td>
<td>BiC</td>
<td>Dry Erase</td>
</tr>
<tr>
<td>Ink Color</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The independent variable(s) are the changing variable(s) and the dependent variable(s) are the height, liquid height, and others.

### SCIENTIFIC PRACTICES

**Conclusions**

1. Directions: Fill in the missing definition.
   - Conclusion: A *claim supported by data*
     - Claim: A statement that can be tested. The explanation of the data, the first part of the claim, supports the data. Example: Cats, on average, weigh less than dogs.
     - Data: Evidence collected from experiment (measurements or observations), the second part of the conclusion.
     - Example: The average weight of a dog is 15 kg, and the average weight of a cat is 5 kg.

2. Directions: Circle if the statement is a CLAIM, DATA, or an OPINION.
   - a. McDonald’s serves fewer customers than Taco Bell servers.
     - Claim: McDonald’s serves fewer customers.
     - Data: Data: McDonald’s serves fewer customers than Taco Bell.
     - Opinion: McDonald’s serves fewer customers than Taco Bell.
   - b. blue is the best color
     - Claim: blue is the best color.
     - Data: People think blue is the best color.
     - Opinion: blue is the best color.
   - c. butterflies are larger than moths.
     - Claim: butterflies are larger than moths.
     - Data: butterflies are larger than moths.
     - Opinion: butterflies are larger than moths.
   - d. ice was observed floating on water.
     - Claim: ice was observed floating on water.
     - Data: ice was observed floating on water.
     - Opinion: ice was observed floating on water.
   - e. people buy more pizza than hamburgers.
     - Claim: people buy more pizza than hamburgers.
     - Data: people buy more pizza than hamburgers.
     - Opinion: people buy more pizza than hamburgers.
   - f. the average male blue whale weighs 50,000 kg, while the average female blue whale weighs 30,000 kg.
     - Claim: the average male blue whale weighs 50,000 kg, while the average female blue whale weighs 30,000 kg.
     - Data: the average male blue whale weighs 50,000 kg, while the average female blue whale weighs 30,000 kg.
     - Opinion: the average male blue whale weighs 50,000 kg, while the average female blue whale weighs 30,000 kg.
   - g. the tomato the fruit the more bugs on the plant.
     - Claim: the tomato the fruit the more bugs on the plant.
     - Data: the tomato the fruit the more bugs on the plant.
     - Opinion: the tomato the fruit the more bugs on the plant.

Circles are your initial thoughts, and boxes are the correct answer.
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 2, picture packet), graph (page 8, student notebook), and conclusion activity (pages 9 and 10, 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.
- 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.

Place the test tubes in the test tube stand and pour all of the liquids that your subgroups need into the small cups. Have all supplies ready so that you can set them out as soon as your subgroups are ready to start.

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 smears?”

Tell them that today they will do 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 2, 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 tallest/shortest smear. They will write an “T” in the box of trial that they think will produce the tallest smear and an “S” in the box of the trial that they think will produce the shortest smear. If they think that all trials will produce the same sized smear, they will write “same” over all boxes. Once this is finished, they can raise their hands and they will receive their experimental supplies from their volunteer.

Tell students that when they record their data, they will make two measurements: the smear height and the liquid height. In addition, they will record any other observations, such as the colors that are observed. Show students where they will record these three things on the results table.

Tell the students that once they have collected their data, they will display their measurements on a graph (page 8, 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 2 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 pen color and the liquid type, what will happen to the height of the smear?” Tell students that in order to make a graph, you will need to follow the checklist on the top of page 8 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: smear height (cm)) on the y-axis (vertical).
Tell students that because your question was about the smear height, you will graph smear height. Write “smear height (cm)” on the y-axis of the graph. When students do their actual experiment, if none of the dots smear, they can go back and modify their question to be “…what will happen to the liquid height” and then plot liquid heights instead of smear heights on their 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 tallest smear can be plotted on the graph. Have the students refer to the results table in the picture packet and ask them to identify the tallest smear that was measured (7.5 cm). Then ask if we would be able to fit this smear height on the graph if we counted by ones. The students should respond yes. When students make their own graphs, they should only count by halves, ones, or twos.
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: liquid type) 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 liquid type and pen color. Record “liquid type” as changing variable #1 and “pen color” 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 2, picture packet, shown below on the left) under the document camera and have students help determine the order that the trials will be graphed (B, D, A then C) 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: soap*) for the trial that you labeled 1 under the first column.

Ask students which trial was labeled 1 (Trial B). Then ask them what you should write next to liquid type and pen color for the first trial. Write “soap” for liquid type and “blue” for pen color on the example notebook.

☐ Graph your data for that trial and write the measurement above the bar.

Ask students what smear height will be graphed for trial A (0 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 “vinegar” for liquid type and “yellow” for pen color on the example notebook. Ask them what the smear height is for this trial (7 cm). Have students help you identify where 7 cm is, draw a line, and write the numerical 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.

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 final height of the smear. Have them write a “T” in the box of the trial they think will produce the tallest smear and an “S” in the box of the trial they think will produce the shortest smear. They will leave two of the boxes empty. If they think all trials will produce the same smear height, have them write “same” over all of the boxes. Try to question each subgroup on their thought process behind their predicted smear heights. See an example notebook in the Experiment section below (left).

Experiment:
(17 minutes – Subgroups – SciTrek Volunteers)

Once subgroups have finished their results table, give them their requested materials. If students are missing any of their experimental materials, the lead box has extra materials. Make sure that students draw their initial dot height line in pencil, not pen, and label their strips A, B, C, and D so they can tell them apart later. As soon as students are done with their liquids, remove the liquids, graduated cylinders, and droppers and put them in the bucket (please do not put trash in the bucket). It is important to do this as soon as possible so students do not play with or spill their liquids. When the experiment is finished, place all test tubes in the bucket and put the corks, test tube stand, timer, and pens in your group box. Once students have finished their experiments, they can record their findings. Make sure that subgroups trace the liquid line (with pencil) onto their strips so they can easily see/measure it later if needed. Once students have finished their measurements, make sure they place their strips in a safe place so that they can attached them to their notebook at the end of the day. If your group has things under control, help other subgroups. As soon as they finish their experiment, they can graph their results. An example of a properly filled out results table is shown below (left).
Graph:
(10 minutes – Subgroups – SciTrek Volunteers)

Help students fill out their graph by having them complete the checklist on page 8. Be sure that students label the y-axis with smear height (or liquid height if needed) and the x-axis with all of their changing variables. If students pick systems in which the dot did not smear, they can go back to page 4 and revise their question from “…what will happen to the height of the smear?” to “…what will happen to the height of the liquid?” Students will need to decide what scale to use on the y-axis. Students can use halves, ones, or twos. Step 4 of the graphing checklist has students label their measurements in increasing order (1-4) on their results table to ensure that they are graphed in increasing order, as seen in the example above. This makes it easier for the students to see trends in their data. In this example, the trials were graphed in the following order: C, D, B, A. Once they have graphed their values, make sure that they write the numerical value of the smear or liquid height 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.

If students finish early, they can start working on the conclusion activity on page 9 of their notebooks by themselves.

Note: It is okay if students do not complete their graph by the time the lead starts the conclusion activity. DO NOT have students go back and finish their graph (even if they only changed one variable). Students that do not finish their graph can present their second experiment and, therefore, will not need their first graph.
**Conclusion Activity:**
*(20 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 15 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.

Tell the students to turn to page 9 in their notebooks while you put the example notebook under the document camera and turn to page 9. 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 9 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: Cats, on average, weigh less than dogs, because the average weight of a dog is 14 kg and the average weight of a cat is 5 kg. 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 14 kg and 5 kg. 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. Read the first statement to students then give them ~15 seconds to circle the answer. Have a student share what they think the correct answer is and why. Have the class vote using thumbs up/thumbs down if they agree/disagree with the student’s reasoning. After the class has come to a consensus, tell students that they will now box the correct answer. Remind them not to erase the original answer because then they will be able to see which concepts/categories they are struggling with. Mark 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 9.

**Letter a:** McDonalds served **100 customers** and Taco Bell served **75 customers**

*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? McDonalds serves more customers than Taco Bell

**Letter b:** blue is the **best** color

*Opinion*

What type of statement is this and how do you know? opinion because it contains the word best
**Letter c:** butterflies that are larger than 15 cm are attracted to bright colors

*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 butterflies that are larger than 15 cm that land on a brightly colored paper and compare that with the number of butterflies that land on black or brown paper

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 at cm).

**Letter d:** ice was observed floating on water

*Data (Data Collected: observed ice and water)*

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?
- ice is less dense than water

**Letter e:** people buy more pizza than hamburgers

*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?
- count the number of people that buy pizza and hamburgers in one day

**Letter f:** the average male blue whale weighs 91,000 kg, while the average female blue whale weighs 122,000 kg

*Data (Data Collected: measured the mass of blue whales (female and male))*

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?
- female blue whales weigh more than male blue whales

**Letter g:** the tastier the fruit the more bugs on the fruit

*Opinion*

What type of statement is this and how do you know?
- *Opinion* because it contains the word tastier

Once part 2 is completed have the students turn to page 10 in their notebooks.

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. Sony TVs are brighter than Samsung TVs, because Sony TVs give off 20 lumens of light and Samsung TVs give off 10 lumens of light.
   This is a correct match because the data clearly supports the claim using numerical values as data to make a conclusion.

2. The color purple is made from blue and red, because when blue and red paint were mixed the paint was observed to turn purple.
   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.

1. Wind turbines produced less energy than solar panels in California, because wind turbines produce 6,000 MW of energy and solar panels produce 5,000 MW of energy in California.
   This is an incorrect match because the data does not support the claim. The claim says that less energy is produced by wind turbines, however, the data supports the opposite claim that solar panels produce less energy. 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.

2. More people read from electronic devices than books, because the speed of light is measured to be $3 \times 10^8 \frac{m}{s}$.
   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.
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. Make sure that all of the liquids and dishes are in the bucket and the bucket’s lid is securely fastened. 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) – 25 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) – 11 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
  - ☐ Chromatography picture packet
  - ☐ Lead lab coat
  - ☐ (3) Materials pages
  - ☐ Time card
  - ☐ (2) Pencils
  - ☐ (2) Red pens
  - ☐ (2) Wet erase markers
  - ☐ Notepad
### SCIENTIFIC PRACTICES

#### Conclusions

<table>
<thead>
<tr>
<th>Variables</th>
<th>Trial A</th>
<th>Trial B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paper Type</td>
<td>3 min.</td>
<td>3 min.</td>
</tr>
<tr>
<td>Liquid Type</td>
<td>Water</td>
<td>Water</td>
</tr>
<tr>
<td>Liquid Amount</td>
<td>3 ml</td>
<td>3 ml</td>
</tr>
<tr>
<td>Pen Type</td>
<td>Original</td>
<td>Original</td>
</tr>
<tr>
<td>Pen Color</td>
<td>Black</td>
<td>Black</td>
</tr>
<tr>
<td>Marking</td>
<td>Mr. Sketch</td>
<td>Crayola</td>
</tr>
<tr>
<td>Initial Dot Height</td>
<td>5 cm</td>
<td>5 cm</td>
</tr>
<tr>
<td>Material</td>
<td>Trial A</td>
<td>Trial B</td>
</tr>
<tr>
<td>Smear Height</td>
<td>3 cm</td>
<td>3 cm</td>
</tr>
<tr>
<td>Liquid Height</td>
<td>3 cm</td>
<td>3 cm</td>
</tr>
<tr>
<td>Other: Yellow</td>
<td>Correct</td>
<td>Correct</td>
</tr>
<tr>
<td>Blue</td>
<td>Correct</td>
<td>Correct</td>
</tr>
<tr>
<td>Red</td>
<td>Incorrect</td>
<td>Incorrect</td>
</tr>
<tr>
<td>Black</td>
<td>Incorrect</td>
<td>Incorrect</td>
</tr>
</tbody>
</table>

**Directions:** Study the following statements and indicate whether each is correct or incorrect. Write a C for correct, I for incorrect. Fill in the spaces as shown on the lines. A correct statement does not agree with the data table. A correct, data correct, or incorrect.

1. a. the paper type affects the height the liquid travels up the paper
2. b. black pen types are made up of different dye colors
3. c. when a black dot sits in water for 5 min, different pen types give different smear heights
4. d. the black crayola was observed to contain green dye

What data can be used to support claim b above? **Black Mr. Sketch** was observed to contain **green dye** and a red dye while **black crayola** was observed to contain **yellow dye**.

### SCIENTIFIC PRACTICES

#### Conclusions

<table>
<thead>
<tr>
<th>Variables</th>
<th>Trial A</th>
<th>Trial B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paper Type</td>
<td>5 min.</td>
<td>4 min.</td>
</tr>
<tr>
<td>Liquid Type</td>
<td>Soap</td>
<td>Soap</td>
</tr>
<tr>
<td>Liquid Amount</td>
<td>3 ml</td>
<td>3 ml</td>
</tr>
<tr>
<td>Pen Type</td>
<td>Original</td>
<td>Original</td>
</tr>
<tr>
<td>Pen Color</td>
<td>Black</td>
<td>Red</td>
</tr>
<tr>
<td>Marking</td>
<td>Mr. Sketch</td>
<td>Mr. Sketch</td>
</tr>
<tr>
<td>Initial Dot Height</td>
<td>3 cm</td>
<td>3 cm</td>
</tr>
<tr>
<td>Material</td>
<td>Trial A</td>
<td>Trial B</td>
</tr>
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<td>1.5 cm</td>
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<td>Liquid Height</td>
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<td>3.5 cm</td>
</tr>
<tr>
<td>Other: Red</td>
<td>Correct</td>
<td>Correct</td>
</tr>
<tr>
<td>Blue</td>
<td>Correct</td>
<td>Correct</td>
</tr>
<tr>
<td>Orange</td>
<td>Incorrect</td>
<td>Incorrect</td>
</tr>
</tbody>
</table>

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

**Table A**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Trial A</th>
<th>Trial B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paper Type</td>
<td>Mr. Sketch</td>
<td>Crayola</td>
</tr>
<tr>
<td>Liquid Type</td>
<td>Water</td>
<td>Water</td>
</tr>
<tr>
<td>Liquid Amount</td>
<td>3 ml</td>
<td>3 ml</td>
</tr>
<tr>
<td>Initial Dot Height</td>
<td>5 cm</td>
<td>5 cm</td>
</tr>
<tr>
<td>Material</td>
<td>Trial A</td>
<td>Trial B</td>
</tr>
<tr>
<td>Smear Height</td>
<td>3 cm</td>
<td>3 cm</td>
</tr>
<tr>
<td>Liquid Height</td>
<td>3 cm</td>
<td>3 cm</td>
</tr>
<tr>
<td>Other: Yellow</td>
<td>Correct</td>
<td>Correct</td>
</tr>
<tr>
<td>Blue</td>
<td>Correct</td>
<td>Correct</td>
</tr>
<tr>
<td>Red</td>
<td>Incorrect</td>
<td>Incorrect</td>
</tr>
<tr>
<td>Black</td>
<td>Incorrect</td>
<td>Incorrect</td>
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</tbody>
</table>

**Table C**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Trial A</th>
<th>Trial B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paper Type</td>
<td>Mr. Sketch</td>
<td>Crayola</td>
</tr>
<tr>
<td>Liquid Type</td>
<td>Water</td>
<td>Water</td>
</tr>
<tr>
<td>Liquid Amount</td>
<td>3 ml</td>
<td>3 ml</td>
</tr>
<tr>
<td>Initial Dot Height</td>
<td>5 cm</td>
<td>5 cm</td>
</tr>
<tr>
<td>Material</td>
<td>Trial A</td>
<td>Trial B</td>
</tr>
<tr>
<td>Smear Height</td>
<td>3 cm</td>
<td>3 cm</td>
</tr>
<tr>
<td>Liquid Height</td>
<td>3 cm</td>
<td>3 cm</td>
</tr>
<tr>
<td>Other: Yellow</td>
<td>Correct</td>
<td>Correct</td>
</tr>
<tr>
<td>Blue</td>
<td>Correct</td>
<td>Correct</td>
</tr>
<tr>
<td>Red</td>
<td>Incorrect</td>
<td>Incorrect</td>
</tr>
<tr>
<td>Black</td>
<td>Incorrect</td>
<td>Incorrect</td>
</tr>
</tbody>
</table>

**Graph D**

<table>
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<tr>
<th>Variables</th>
<th>Trial A</th>
<th>Trial B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paper Type</td>
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<td>Crayola</td>
</tr>
<tr>
<td>Liquid Type</td>
<td>Water</td>
<td>Water</td>
</tr>
<tr>
<td>Liquid Amount</td>
<td>3 ml</td>
<td>3 ml</td>
</tr>
<tr>
<td>Initial Dot Height</td>
<td>5 cm</td>
<td>5 cm</td>
</tr>
<tr>
<td>Material</td>
<td>Trial A</td>
<td>Trial B</td>
</tr>
<tr>
<td>Smear Height</td>
<td>3 cm</td>
<td>3 cm</td>
</tr>
<tr>
<td>Liquid Height</td>
<td>3 cm</td>
<td>3 cm</td>
</tr>
<tr>
<td>Other: Yellow</td>
<td>Correct</td>
<td>Correct</td>
</tr>
<tr>
<td>Blue</td>
<td>Correct</td>
<td>Correct</td>
</tr>
<tr>
<td>Red</td>
<td>Incorrect</td>
<td>Incorrect</td>
</tr>
<tr>
<td>Black</td>
<td>Incorrect</td>
<td>Incorrect</td>
</tr>
</tbody>
</table>

Can this person make a claim/conclusion? **NO**

Can this person make a claim/conclusion? **YES**

### Making a Conclusion from Your Data

How many changing variables did you have in your experiment? **3**

Can you make a conclusion from your data? **YES**

**IF NO**

Why? I cannot make a conclusion because I changed more than 1 variable in my experiment.

**IF YES**

We can conclude ________

because ________

**Table Approval**

SciTrek Member Approval **YES**
Changing Variable(s) (Independent Variable(s))

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

Changing Variable 1: pen color
Changing Variable 2 (optional): ____________________________
Changing Variable 3 (optional): ____________________________

QUESTION

Question our group will investigate:

- if we change the pen color, what will happen to the ________________ of the smear?

SciTrek Member Approval ____________

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

EXPERIMENTAL SET-UP

Determine the values of your changing variable(s) (ex: pen color) from the materials page and write the values (ex: blue) for your four trials under each strip of paper.

Changing Variable(s):

1) pen color ______ purple, light green, orange, black
2) ______
3) ______
4) ______

Controls (variables you will hold constant):

Determine the variables that you will hold constant and indicate the specific value you will use in all your trials.

Container / Test Tube

<table>
<thead>
<tr>
<th>pen type</th>
<th>Mr. Sketch</th>
</tr>
</thead>
<tbody>
<tr>
<td>liquid type</td>
<td>water</td>
</tr>
<tr>
<td>dot height / 2 cm</td>
<td></td>
</tr>
<tr>
<td>liquid amount / 5 mL</td>
<td></td>
</tr>
<tr>
<td>time / 4.6 min</td>
<td></td>
</tr>
<tr>
<td>paper type / original cork placement on</td>
<td></td>
</tr>
</tbody>
</table>

SciTrek Member Approval ____________

PROCEDURE

Procedure Note:

Make sure to include all values of your changing variable(s) in the procedure. (Example, for a group that decided to change pen color, one step would be put colored dot with Mr. Sketch pens: E) red, F) blue, G) green, and H) yellow on original paper at x cm.)

1. Fill 4 test tubes with 5 mL of water.

2. Put a dot 2 cm high on original paper with a E) purple, F) light green, G) orange, H) black Mr. Sketch marker.

3. Put paper in test tube and put cork on.

4. Wait for 4.6 minutes.

5. Remove papers.

6. Measure smear height and observe smear colors.

SciTrek Member Approval ____________

SciTrek Member Approval ____________
Set-Up:

SciTrek Lead:
If the classroom has a document camera, ask the teacher to use it for the conclusion activity (pages 11-13, 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.

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 analyze other scientists’ 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:
(25 minutes – Full Class – SciTrek Lead)

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 and a statement that can be tested. 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 to turn to page 11 in their notebooks. Place an example notebook under the document camera and open to page 11.

Have students annotate the results table. As a group, identify and then circle the changing variable (pen type), underline the controls (time, liquid type, liquid amount, paper type, pen color, and initial dot height), and box the information about the data collected (smear height, liquid height, and other).

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 paper type affects the height the liquid travels up the paper  

*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?  
Paper type (circle paper type)  
Is paper type a changing variable in this experiment?  
No  
What should we circle?  
Incorrect  

**Letter b:** black pen types are made up of different dye colors  

*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?  
Pen type (circle pen type)  
Is pen type 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 black dot sits in water for 5 min, different pen types give different smear heights  

*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?  
Pen type (circle pen type)  
Is the 5 minutes data?  
No, it is a descriptive number (one of the controls) (underline 5 min)  
Are there any other controls in this statement?  
Black (underling black)  
Is pen type a changing variable in this experiment?  
Yes  
Is the claim consistent with the data?  
Yes  
What should we circle?  
Correct claim
**Letter d:** the **black [Crayola]** was observed to contain **green dye**

*Data/Incorrect*

What type of statement is this and how do you know?
- **Data** because it contains an observation (write D on the line and box green dye)

What is black Crayola?
- Black is a control and Crayola is a changing variable (underline black and circle Crayola)

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 (black pen types are made up of different dye colors) and ask the students what data can be used to support this claim. They should respond that black Mr. Sketch was observed to contain green, blue, and red dyes while black Crayola contained yellow, blue, and red dyes. 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 observations. In the statement, underline the word “black,” (two times) box the words “green, blue, and red dyes” and “yellow, blue, and red dyes” and circle the words “Mr. Sketch” and “Crayola.”

Then read the complete conclusion: black pen types are made up of different dye colors because **black Mr. Sketch** was observed to contain **green, blue, and red dyes** while **black Crayola** contained **yellow, blue, and red dyes**.

If there is time, you can have the students determine the data to support claim c: the smear height for Mr. Sketch was 3 cm while the smear height for Crayola was 2 cm. This is data because it contains a measurement. Box the measurements in the statement and circle the changing variable values.

---

**SCIENTIFIC PRACTICES**

**Conclusions**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Trial A</th>
<th>Trial B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black</td>
<td>5 cm</td>
<td>3 cm</td>
</tr>
<tr>
<td>Liquid Type</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liquid Amount</td>
<td>3 ml</td>
<td>2 ml</td>
</tr>
<tr>
<td>Paper Type</td>
<td>Original</td>
<td>Crayola</td>
</tr>
<tr>
<td>Variation</td>
<td>Black</td>
<td>Mr. Sketch</td>
</tr>
<tr>
<td>Smear Height</td>
<td>3 cm</td>
<td>2 cm</td>
</tr>
</tbody>
</table>

**Final Observations:**

<table>
<thead>
<tr>
<th>Measurements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smear Height</td>
</tr>
<tr>
<td>Liquid Amount</td>
</tr>
<tr>
<td>Paper Type</td>
</tr>
<tr>
<td>Variation</td>
</tr>
<tr>
<td>Smear Height</td>
</tr>
<tr>
<td>Liquid Amount</td>
</tr>
<tr>
<td>Paper Type</td>
</tr>
<tr>
<td>Variation</td>
</tr>
</tbody>
</table>

**Step 2:**

- **Correct Claim:** the paper type affects the height the liquid travels up the paper
- **Correct Data:** black pen types are made up of different dye colors
- **Correct Claim:** when a black dye dots in water for 5 min, different pen types give different smear heights
- **Correct Data:** the black Crayola was observed to contain green dye

What data can be used to support claim b above?
- **Correct Claim:** black Mr. Sketch was observed to contain green, blue, and red dyes.
- **Correct Data:** while black Crayola was observed to contain yellow, blue, and red dyes.

---

Have students turn to page 12 in their notebooks. Turn the example notebook to page 12.
Have students annotate the results table. As a group, identify and then circle the changing variables (time, liquid type, and pen color), underline the controls (liquid amount, paper type, pen type, and initial dot height), and box the information about the data collected (smear height, liquid height, and other).

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 stronger the pen odor the larger the smear height

*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?
- Pen odor (circle pen odor)

Is pen odor a changing variable in this experiment?
- No

What should we circle?
- Incorrect

**Letter b:** the black pen had a smear height of 3 cm and the red pen had a smear height of 1.5 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 3 cm and 1.5 cm)

What are black and red?
- Black and red are both changing variables (circle black and red)

Is the data correct based on the results table?
- Yes

What should we circle?
- Correct data

**Letter c:** black and red pens are made from green dye

*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?
- Pen color (circle black and red pens and write pen color over the statement)

Is pen color a changing variable in this experiment?
- Yes

Is the claim consistent with the data?
- No

What should we circle?
- Incorrect
**Letter d:** the thicker the liquid the shorter the smear height

*Claim/Incorrect (More than One Changing Variable)*

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

Claim because it can be tested

What would need to be the changing variable for this claim to be correct?

Liquid type (circle thicker the liquid and write liquid type above the statement)

Is liquid type a changing variable in this experiment?

Yes

Is the claim consistent with the data?

Yes

Is this claim fair or could the smear height be changing because of another reason?

This claim is not fair because the smear height could have changed as a result of changing the time or the pen color

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 smear. 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.

---

**Scientific Practices**

**Conclusions**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Trial A</th>
<th>Trial B</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Liquid Type</strong></td>
<td>Water</td>
<td>Soap</td>
</tr>
<tr>
<td><strong>Liquid Amount</strong></td>
<td>2 ml</td>
<td>2 ml</td>
</tr>
<tr>
<td><strong>Paper Type</strong></td>
<td>Original</td>
<td>Original</td>
</tr>
<tr>
<td><strong>Pen Color</strong></td>
<td>Black</td>
<td>Red</td>
</tr>
<tr>
<td><strong>Pen Type</strong></td>
<td>Mr. Sketch</td>
<td>Mr. Sketch</td>
</tr>
<tr>
<td><strong>Initial Dot Height</strong></td>
<td>3 cm</td>
<td>3 cm</td>
</tr>
</tbody>
</table>

**Final Observations/Measurements:**

<table>
<thead>
<tr>
<th></th>
<th>Trial A</th>
<th>Trial B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smear height</td>
<td>3 cm</td>
<td>1.5 cm</td>
</tr>
<tr>
<td>Liquid height</td>
<td>5 cm</td>
<td>3.5 cm</td>
</tr>
<tr>
<td>Other</td>
<td>Green</td>
<td>Red</td>
</tr>
</tbody>
</table>

**Steps:**

a. The stronger the pen the larger the smear height | Correct Claim Correct Data Correct
b. The pen used had a smear height of 1.5 cm and the pen used had a smear height of 5 cm | Correct Claim Correct Data Correct

**Steps:**

c. Red pens are made from liquid type | Correct Claim Correct Data Incorrect
d. The thicker the liquid the shorter the smear height | Correct Claim Correct Data Incorrect

If no claim can be made from the data state why not: **No Claim Can Be Made Because There Is More Than 1 Changing Variable**

If no claim can be made from the results, can you make a conclusion? | YES | NO
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)?
  - Time, pen type, and liquid amount
- 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)?
  - Paper type
- Can a claim/conclusion be made from this data?
  - Yes
- Did the paper type affect the smear height?
  - Yes
Table C

<table>
<thead>
<tr>
<th>How many changing variables are there?</th>
</tr>
</thead>
<tbody>
<tr>
<td>One</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>What is/are the changing variable(s)?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pen type</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Can a claim/conclusion be made from this data?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Did the pen type effect the smear height?</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
</tr>
</tbody>
</table>

Graph D

<table>
<thead>
<tr>
<th>How many changing variables are there?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>What is/are the changing variable(s)?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pen color and liquid amount</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Can a claim/conclusion be made from this data?</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Why not?</th>
</tr>
</thead>
<tbody>
<tr>
<td>This experiment had two changing variables and conclusions/claims can only be made when there is one changing variable.</td>
</tr>
</tbody>
</table>

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 smears?) 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 14 of their notebook. 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 observations) and that these statements are in the appropriately labeled sections. Conclusions are still valid, and important, if they show that the changing variable tested did not affect the smear. 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.

**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 smears.

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 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 liquid amounts, dot heights, and times that are within the limitations given on the materials page. An example of a materials page is shown in the Experimental Set-Up section.

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

Have subgroups use the materials page to fill in their experimental set-ups on page 16 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 and materials page are shown below.
 Procedure:

(11 minutes – Subgroups – SciTrek Volunteers)

After each subgroup has filled out their experimental set-up, they can start on their procedure (page 17). 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 pen color as a changing variable would be, “Put colored dot with Mr. Sketch pen E) red, F) blue, G) green, and H) yellow on original paper at 2 cm.” 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 6 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 finish, they should raise their hand and get their procedure approved by their volunteer. An example procedure can be seen below.

If subgroups have extra time, have them fill out their results table.
Wrap-Up: (2 minutes – Full Class – SciTrek Lead)

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: Results Table/Experiment/Graph/Conclusion

Schedule:
- Introduction (SciTrek Lead) – 20 minutes
- Results Table (SciTrek Volunteers) – 5 minutes
- Experiment (SciTrek Volunteers) – 20 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
- ☐ (3) Pencils
- ☐ (2) Red pens
- (3) Ziploc bags with the following: (labeled with subgroup number)
  - ☐ (2) 10 mL Graduated cylinders
  - ☐ (4) Corks
  - ☐ (2) Droppers
- ☐ Notepad
- ☐ (6) Rulers
- ☐ Paper towels
- ☐ Water
- ☐ (3) Test tube stands
- ☐ (12) Small cups (labeled with liquid types)
- ☐ Vinegar
- ☐ Soap
- ☐ Rubbing alcohol

Other Supplies:
- ☐ Box of test tubes
- ☐ Bucket with lid

Lead Box:
- ☐ (3) Extra student notebooks
- ☐ Lead instructions
- ☐ Chromatography picture packet
- ☐ Lead lab coat
- ☐ Time card
- ☐ (2) Pencils
- ☐ (2) Red pens
- ☐ (2) Wet erase markers
- ☐ Notepad
- ☐ (6) Rulers
- ☐ (2) Timers
- ☐ Water
- ☐ (2) Test tube stands
- ☐ Vinegar
- ☐ Soap
- ☐ Rubbing alcohol
- ☐ Bag 1: lead chromatography supplies ((4) 10 mL graduated cylinders, (10) corks, (8) droppers, (12) small cups (labeled with liquid types), paper towels)
- ☐ Bag 2: lead chromatography supplies (chromatography paper (minimum 30), 6 paper types (minimum 20 each), 8 different black pens, 5 sets of different colored markers)
**SCIENTIFIC PRACTICES**

**Conclusions**

Question: If we change the paper height, what will happen to the liquid height?

<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>Containers</td>
<td>Test Tube</td>
<td>Test Tube</td>
<td>Test Tube</td>
<td>Test Tube</td>
</tr>
<tr>
<td>Time</td>
<td>5 min</td>
<td>5 min</td>
<td>5 min</td>
<td>5 min</td>
</tr>
<tr>
<td>Liquid Type</td>
<td>Water</td>
<td>Water</td>
<td>Water</td>
<td>Water</td>
</tr>
<tr>
<td>Liquid Amount</td>
<td>2 mL</td>
<td>2 mL</td>
<td>2 mL</td>
<td>2 mL</td>
</tr>
<tr>
<td>Paper Type</td>
<td>Original</td>
<td>Original</td>
<td>Original</td>
<td>Original</td>
</tr>
<tr>
<td>Pen Color</td>
<td>Black</td>
<td>Black</td>
<td>Black</td>
<td>Black</td>
</tr>
<tr>
<td>Pen Type</td>
<td>Mr. Sketch</td>
<td>Mr. Sketch</td>
<td>Mr. Sketch</td>
<td>Mr. Sketch</td>
</tr>
<tr>
<td>Initial Paper Height</td>
<td>5 cm</td>
<td>10 cm</td>
<td>15 cm</td>
<td>20 cm</td>
</tr>
</tbody>
</table>

**Data**

<table>
<thead>
<tr>
<th>Initial Observations</th>
<th>Measurement</th>
<th>Initial Observations</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smear Height</td>
<td>3 cm</td>
<td>Smear Height</td>
<td>3 cm</td>
</tr>
<tr>
<td>Liquid Height</td>
<td>5 cm</td>
<td>Liquid Height</td>
<td>5 cm</td>
</tr>
<tr>
<td>Color</td>
<td>blue</td>
<td>Color</td>
<td>red</td>
</tr>
<tr>
<td>Other</td>
<td>orange</td>
<td>orange</td>
<td>red</td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Write conclusion from the results above:

We can conclude that the liquid will reach the top of the paper if the paper is 11 cm or shorter because when the paper height was 6 cm, the liquid height was 6 cm (same as the paper height) and when the paper height was 11 cm, the liquid height was only 11 cm (not the top of the paper).

**RESULTS**

**Table**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Trial E</th>
<th>Trial F</th>
<th>Trial G</th>
<th>Trial H</th>
</tr>
</thead>
<tbody>
<tr>
<td>Containers</td>
<td>Test Tube</td>
<td>Test Tube</td>
<td>Test Tube</td>
<td>Test Tube</td>
</tr>
<tr>
<td>Time</td>
<td>4.5 min</td>
<td>4.5 min</td>
<td>4.5 min</td>
<td>4.5 min</td>
</tr>
<tr>
<td>Liquid Type</td>
<td>Water</td>
<td>Water</td>
<td>Water</td>
<td>Water</td>
</tr>
<tr>
<td>Liquid Amount</td>
<td>6 mL</td>
<td>6 mL</td>
<td>6 mL</td>
<td>6 mL</td>
</tr>
<tr>
<td>Paper Type</td>
<td>Original</td>
<td>Original</td>
<td>Original</td>
<td>Original</td>
</tr>
<tr>
<td>Pen Color</td>
<td>purple, light green, orange, black</td>
<td>purple, light green, orange, black</td>
<td>purple, light green, orange, black</td>
<td>purple, light green, orange, black</td>
</tr>
<tr>
<td>Pen Type</td>
<td>Mr. Sketch</td>
<td>Mr. Sketch</td>
<td>Mr. Sketch</td>
<td>Mr. Sketch</td>
</tr>
<tr>
<td>Initial Paper Height</td>
<td>7 cm</td>
<td>7 cm</td>
<td>7 cm</td>
<td>7 cm</td>
</tr>
<tr>
<td>Cork placement</td>
<td>on</td>
<td>on</td>
<td>on</td>
<td>on</td>
</tr>
</tbody>
</table>

**Predictions**

Fill out the chart for each of your trials. If one of the variables remains constant for all trials, write the value in Trial A and then draw a line through each box indicating that this variable is constant.

<table>
<thead>
<tr>
<th>Data</th>
<th>Trial E</th>
<th>Trial F</th>
<th>Trial G</th>
<th>Trial H</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smear Height</td>
<td>3.5 cm</td>
<td>3.5 cm</td>
<td>3.5 cm</td>
<td>4 cm</td>
</tr>
<tr>
<td>Liquid Height</td>
<td>6 cm</td>
<td>5.5 cm</td>
<td>6 cm</td>
<td>6 cm</td>
</tr>
<tr>
<td>Color</td>
<td>purple, light green, orange, black</td>
<td>purple, light green, orange, black</td>
<td>purple, light green, orange, black</td>
<td>purple, light green, orange, black</td>
</tr>
</tbody>
</table>

**CONCLUSION**

We can conclude that the pen color does not greatly affect the smear height, but does affect the color of the smear.

What data do you have to support your claim?

(Example: The smear height for the light green and purple pens were 3.5 cm, but we observed the smear for the light green pen contained yellow, green, blue, and yellow while the smear for the purple pen contained purple, light purple, and pink.)

Can you test the first part (claim) of the conclusion?

[ ] Yes [ ] No

(If you checked this box go back and revise your claim so that it can be.)

The second part of the conclusion is data because it contains an observation:

I acted like a scientist when I... observed the color of the smears and measured the smear heights.
**Set-Up:**

**SciTrek Lead:**

If the classroom has a document camera, ask the teacher to use it for the conclusion example (page 18, student notebook). 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.

Place the test tubes in the test tube stand and pour all of the liquids that your subgroups need into the small cups. Have all supplies ready so that you can set them out as soon as your subgroups are ready to start.

**Introduction:**

*(20 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 smears?” 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 smear.

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 18 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 paper height. Have students circle paper height. Next, have students identify and underline the controls for the experiment. Students should underline container, time, liquid type, liquid amount, paper type, pen color, pen type, and initial dot height. Lastly, have students identify the data the scientists collected and box that information. Students should box smear height, liquid height, and other. Ask students what the question was that these scientists were exploring. They should reply, “If we change the paper height, what will happen to the liquid height?” 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.

Next, draw a picture on the board of what happened in each trial. Ask the students what the paper height was for trial A (5cm). Draw the paper on the board and label it A. Then ask the students where the dot was on the paper (2 cm), and draw a line and dot proportionate to the paper sizes at what would be 2 cm. Next ask the students what the liquid height was for trial A (5 cm) and if this was at the top of the paper
(yes). Draw a wavy line to represent the water at the appropriate height. Ask the students what the smear height was for trial A (3 cm). Ask them why the smear height is shorter than the water height. Students should realize that the smear height starts at the line (2 cm from the bottom of the strip) and the water level starts at the bottom of the strip. Draw on the smear starting at the line with the dot. Repeat the process for the other trials (see example drawing below). Ask students if they see any trends in the liquid heights. Students should say that the liquid heights for the 10 cm and 5 cm papers reached the top of the paper, but the liquid heights for the 15 cm and 20 cm papers were both 11 cm. Next, have students make several predictions about what would happen to the liquid and smear height if the paper height was several different sizes. For example: if the paper height was 8 cm, would the liquid reach the top of the paper? (Yes). If the paper height was 13 cm, would the liquid reach the top of the paper? (No). After making several predictions, ask the students what is the tallest paper height that would still allow the liquid to reach the top of the paper (11 cm). After students have a clear idea of what happened in the experiment, tell them that we are going to determine an appropriate conclusion for this data.

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 drawings and make a claim that tries to explain these results?” Example claims that state how the liquid height is affected by the paper height:

1. the liquid will reach the top of the paper if the paper is 11 cm or shorter
2. if the paper height is larger than 11 cm, the paper height will not affect liquid height.

Example claim that states what happened

1. the paper height affects the liquid height

If possible, try to lead the students to a claim that explains how the liquid height was affected instead of a claim that just states what happened to the liquid height. The underlined dotted claim above is the claim that most classes generate. 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 are examples of data that supports claims that stated how the liquid was affected. The underlined dotted data below corresponds to the underlined dotted claim above.

1. when the paper height was 5 cm, the liquid height was 5 cm (same as the paper height) and when the paper height was 20 cm, the liquid height was only 11 cm (not the top of the paper)
2. when the paper height was 15 cm and 20 cm, the liquid height was 11 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.

**Teacher Note:** If the experimental question was asked about the smear height or the smear color, below are appropriate conclusions for those questions.

1. If the paper height is greater than 11 cm, the smear height will be 9 cm, because when the paper height was 20 cm and 15 cm the smear height was 9 cm.
2. If the liquid level is the same as the paper height, then the smear height will be 2 cm shorter than the paper height, because when the paper height was 10 cm and 5 cm and the liquid height was the same as the paper height, the smear heights were 8 cm and 3 cm respectively, both were 2 cm shorter than the paper height.
3. The height of the paper affects the smear, because when the paper height was 20 cm, the smear height was 9 cm and when the paper height was 10 cm, the smear height was 8 cm.
4. The colors that the black dot separates into are the same, regardless of the paper height, because the colors of the smears were observed to be blue, orange, and red for all four trials.
5. The height of the paper does not affect the colors of the smear, because the colors of the smears were observed to be blue, orange, and red for all four trials.

Today, students will run their second experiment, complete their graph, and draw a conclusion from their data. Remind students that they must have their procedure and results table completed before they can start their experiment.
Results Table:
(5 minutes – Subgroups – SciTrek Volunteers)

If your subgroup has not finished their procedure, make sure they do this before moving on to their results table.

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 final height of the smear. Have them write a “T” in the box of the trial they think will produce the tallest smear and an “S” in the box of the trial they think will produce the shortest smear. They will leave two of the boxes empty. If they think all trials will be the same height, have them write “same” over all of the boxes. See example notebook above. Try to question each subgroup on their thought process behind their predicted smear heights. See example notebook in Introduction above (right).

Experiment:
(20 minutes – Subgroups – SciTrek Volunteers)

Once subgroups have finished their result table, give them their requested materials. If students are missing any of their experimental materials, the lead box has extra materials. Make sure that students draw their initial dot height line in pencil, not pen, and label their strips E, F, G, and H so they can tell them apart later. As soon as students are done with their liquids, remove the liquids, graduated cylinders, and droppers and put them in the bucket (please do not put trash in the bucket). It is important to do this as soon as possible so students do not play with or spill their liquids. When the experiment is finished, place all test tubes in the bucket and put the corks, test tube stand, timer, and pens in your group box.

Once students have finished their experiments, they can record their findings. Make sure that subgroups trace the liquid line (with pencil) onto their strips so they can easily see/measure it later if needed. Once students have finished their measurements, make sure they place their strips in a safe place so that they can attached them to their notebook at the end of the day. These strips will be attached to their posters during the poster making session. If your group has things under control, help other subgroups. As soon as they finish their experiment, they can graph their results. 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 20. Be sure that students label the y-axis with smear height (or liquid height if needed) and the x-axis with their changing variable. If students pick systems in which the dot did not smear, they can go back to page 15 and revise their question from “what will happen to the height of the smear?” to “what will happen to the height of the liquid?” Students will need to decide what scale to use on the y-axis. Students can use halves, ones, or twos. Step 3 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: G, F, E, H. Once they have graphed their values, make sure that they write the numerical value of the smear or liquid height on top of each column so that it is easy to quickly read the graph. An example of a properly filled out graph in show 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 smear or liquid height.

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 students are going to make a claim about the liquid height instead of the smear height, have them go back and revise their question on page 15.

If the values of their changing variable have an order (example: 1 min $\rightarrow$ 3 min $\rightarrow$ 5 min), then that variable affected the smear height. If, on the other hand, there was no order for their changing variable values (example: 0.5 cm $\rightarrow$ 1 cm mL $\rightarrow$ 1.5 cm) and the difference between the smear heights for each trial is small, then that variable did not affect the smear height. 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) their changing variable did or did not affect their measurements instead of just what happened (claim 3 and 4 below). For this experiment, we will not focus on why the dot is spreading up the paper.

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

Claim 1: the more absorbent the paper the larger the smear
Claim 2: the more time the taller the smear
Example claims that state what happened to the smear.

Claim 3: the paper type affected the height of the smear
Claim 4: the color of the pen did not affect the height of the smear

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 21, student notebook).

Conclusions are still valid, and important, if they show that the changing variable tested did not affect the smear. 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.

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. Show students how to attach their strips to the front of their notebooks so they will have them next time when they make their poster.

Clean-Up:

Before you leave, have students attach their nametag to their notebook and place them in the group box. Have one student of each group attach their experiment strips to their notebook with their nametag. Make sure that all of the liquids and dishes are in the bucket and the bucket’s lid is securely fastened. 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
- □ Student notebooks
- □ Volunteer instructions
- □ Volunteer lab coat
- □ Poster diagram
- □ (3) Stickers on how to present graph

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

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

Other Supplies:
- □ Poster paper tube

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

□ (3) Stickers on how to present graph
□ (2) Pencils
□ (2) Wet erase markers
□ Notepad
□ (9) Paperclips

□ (2) Highlighters
□ (2) Scissors
□ (2) Glues
□ Scotch tape
□ (3 each color)Poster part packs

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 smears?” 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 that when scientists complete their experiment, they make a poster to present their work to other scientists; 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 four claims that were previously listed:
- **Data 1:** the smear on the paper towel (most absorbent) was 3 cm and the smear on the copy paper (least absorbent) was 0.5 cm
- **Data 2:** the strip that sat in the liquid for 1 minute had a 1 cm smear and the strip that sat in the liquid for 5 minutes had a 4 cm smear
- **Data 3:** the smear on the paper towel was 3 cm and the smear on the copy paper was 0.5 cm
- **Data 4:** all of the smears by the Mr. Sketch pens, regardless of color, were about 3 cm long

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 21, 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 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>
</tr>
</thead>
</table>
| 3                             | 1. Question and Experimental Set-Up  
2. Procedure  
3. Results Graph* and Conclusion  
Student that finishes 1st completes the results table (not presented) |
| 4                             | 1. Question and Experimental Set-Up  
2. Procedure  
3. Results Graph*  
4. Conclusion  
Student that finishes 1st completes the results table (not presented) |

*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 20, student notebook).

| The _______________________ for____________ was ___________________. |
| what was measured | changing variable value | measurement |

Then practice reading the four sentences with that student. For the poster below, the first sentence would be: The smear height for rubbing alcohol was 4.5 cm. Make sure you fill in the first blank (example: smear height) in the sentence frame for the student but leave the second two blanks (“changing variable 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 smear height or liquid height for values of their changing variable that they did not test. For instance, if the subgroup’s conclusion was, “the thicker the liquid the smaller the smear, because soap gave a 1 cm smear height and water gave a 6 cm smear height,” ask the subgroup to predict the smear height if the liquid was honey. They should be able to predict that it would be less than 1 cm because honey is thicker than soap.

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
  - ☐ Student notebooks
  - ☐ Volunteer instructions
  - ☐ Volunteer lab coat
  - ☐ (2) Pencils
  - ☐ (9) Paperclips
  - ☐ Highlighter

- Lead Box:
  - ☐ (3) Extra student notebooks
  - ☐ Lead lab coat
  - ☐ (2) Pencils
  - ☐ Lead instructions
  - ☐ Time card
  - ☐ (2) Wet erase markers
  - ☐ Chromatography picture packet
  - ☐ Teacher Final Survey QR code
  - ☐ (9) Paperclips
  - ☐ (3) Stickers on how to present graph
  - ☐ (2) Highlighters
  - ☐ 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 3 and 4, picture packet). If the classroom does not have a document camera, then write the class question on the board, “What variables affect smears?” 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.

Give the teacher the QR code and ask them to take the survey at the website about their experiences with the SciTrek program.

SciTrek Volunteers:

Set out the notebooks/nametags. Today students will be sitting in their regular classroom seats during poster presentations.
**Picture Packet Pages:** (Student notebook pages 22 and 23 are almost identical to picture packet pages 3 and 4, but have one less subgroup space.)

**NOTES ON PRESENTATIONS**

<table>
<thead>
<tr>
<th>Subgroup 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Changing Variable:</td>
</tr>
<tr>
<td>Smear Height (cm):</td>
</tr>
<tr>
<td>Summary:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Subgroup 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smear Height (cm):</td>
</tr>
<tr>
<td>Summary:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Subgroup 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Changing Variable:</td>
</tr>
<tr>
<td>Smear Height (cm):</td>
</tr>
<tr>
<td>Summary:</td>
</tr>
</tbody>
</table>

**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 smears?” Tell students that during the presentations they are going to take notes. Have them turn to page 22 in their notebook while you turn to page 3 of the picture packet. Tell them that they need to record each subgroup’s changing variable 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 smear. 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.

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 smears?” 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 thinner the liquid, the taller the liquid/smear height.
- Different liquids will change the order the colors appear in the smear, but not what colors appear.
- The more absorbent the paper, the taller the liquid/smear height.
- If the liquid level is above the dot, the smear will travel downwards. If the liquid level is below the dot, the smear will travel upwards.
- Different black pens are made up of different dye colors.
- Colored markers separate into fewer colors than black markers.
- The longer the time, the taller the liquid/smear height.

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 most colorful smear and that you need them to tell you what values of variables you should use.

- Time: As long as possible
- Liquid type: Water or another thin liquid
- Liquid Amount: Enough to get the liquid close to the dot without going over the dot
- Paper Type: The original paper or another absorbent paper
- Pen Color: Black
- Pen Type: Any washable marker
- Initial Dot Height: A value that would put the dot close to the liquid level

If no one in the class did experiments on one of the variables above, then they will not know how that variable affects smear height, so do not expect them to tell you which value to use. Tell students they have taught you a lot about the smears.

**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.

**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: Tie to Standards/Content Assessment

**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:**

<table>
<thead>
<tr>
<th>Times if teacher gave assessment prior to SciTrek</th>
<th>Times SciTrek must give assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Draw a Scientist (SciTrek Lead) – 5 minutes</td>
<td>Conclusion Assessment (SciTrek Lead) – 10 minutes</td>
</tr>
<tr>
<td>Tie to Standards (SciTrek Lead) – 45 minutes</td>
<td>Draw a Scientist (SciTrek Lead) – 5 minutes</td>
</tr>
<tr>
<td>Content Assessment (SciTrek Lead) – 10 minutes</td>
<td>Tie to Standards (SciTrek Lead) – 35 minutes</td>
</tr>
<tr>
<td>Content Assessment (SciTrek Lead) – 10 minutes</td>
<td></td>
</tr>
</tbody>
</table>

**Materials:**

Lead Box:
- ☐ (3) Extra student notebooks
- ☐ Student notebooks
- ☐ Lead instructions
- ☐ Chromatography picture packet
- ☐ TTS Box
- ☐ Jar of sand and water
- ☐ (2) Markers

□ Lead lab coat
□ (35) Conclusion assessments
□ (35) Draw a scientist
□ (35) Content assessments
□ Time card
□ (20) Pure substance bags labeled (sugar, salt, baking soda, and corn starch)
□ (2) Pencils
□ (2) Wet erase markers
□ Matter Poster
□ Teacher final survey QR code
□ (20) Pure substance bags labeled with letters (A=baking soda, B= sugar, C= salt, and D= corn starch)
**Notebook Pages and Chart:**

### TIE TO STANDARDS
1. Circle the value of the variable that the police should use to process the evidence from the suspects that would give them the tallest smear.
   - Time: 3 min 5 min 10 min
   - All would give similar height smears
   - Liquid Type: Water Soap Syrup
   - All would give similar height smears
   - Amount of Liquid/Line Level:  

2. What conclusion can you make from the results the police collected?

   We can conclude that the robber was number __four__.
   
   because it was observed that the ink from the letter and number four were the same height and color.

3. What did we learn about black ink? It is a mixture.

4. Fill in the following works on the chart: physical properties, pure substance, matter, mixture.

   **Matter Chart**

5. Physical property: Property that can be measured or observed without changing the substance.

6. Physical properties of black ink are: __black__ and __liquid__.

7. Physical properties of paper are: __white__ and __smooth__.

8. Can all physical properties be used to separate mixtures? __Yes__

9. What type of physical property was use to separate the black ink?

   __Attraction to water and paper__

10. What do we know about the yellow ink?

   __Attracted to paper__

11. What do we know about the blue ink?

   __Attracted to water__

12. Determine how you would separate each mixture into two parts.

<table>
<thead>
<tr>
<th>Mixture</th>
<th>List 3 Physical Properties of each part of the mixture</th>
<th>Helpful in Separating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td><strong>Liquid</strong> solid</td>
<td>(circle one)</td>
</tr>
<tr>
<td>Sand</td>
<td><strong>Clear</strong> brown</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Light</strong> heavy</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

   Is water a pure substance? __Yes__
   Is sand a pure substance? __No__

13. Physical properties can be used to separate mixtures and identify pure substances.

14. Write down physical properties of the four substances. You will use these to identify four unknown substances. You will not have access to the labeled substances when you are identifying the unknown substances.

<table>
<thead>
<tr>
<th>Pure Substance</th>
<th>Physical Properties</th>
<th>Unknown Letter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sugar</td>
<td>brown, small granules, many edges, irregular shape</td>
<td>B</td>
</tr>
<tr>
<td>Salt</td>
<td>white powder, square shaped pieces</td>
<td>C</td>
</tr>
<tr>
<td>Baking Soda</td>
<td>white powder, edges to sides of bag, crinkles when pinched</td>
<td>A</td>
</tr>
<tr>
<td>Corn Starch</td>
<td>white powder, edges to sides of bag, crinkles when pinched</td>
<td>D</td>
</tr>
</tbody>
</table>
**Set-Up:**

**SciTrek Lead:**

Ask the teacher if they took the SciTrek final survey. If they have not, give them the QR code and ask them to take the survey on the website about their experiences with the SciTrek program.

If the classroom has a document camera, ask the teacher to use it for the Tie to Standards activity (pages 24-26, student notebook) and Tie to Standards pictures (pages 1, 5, and 6, 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.

Tape the matter chart to the board.

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 – Given by Classroom Teacher Prior to SciTrek)*

“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.
For page 4, read the three Attitudes Towards Science questions to students and have them answer them. When they are finished, collect the assessments and verify that the students’ names are on the top of the papers.

**Draw a Scientist:**
*(5 minutes – Full Class – SciTrek Lead)*

Pass out the draw a scientist paper. Tell students to fill out their name, teacher’s name, and date on the top of the assessment. Give students **exactly 4 minutes** to draw a picture of a scientist. Once they are done, ask them to write on the bottom line who they drew a picture of. If it was no one specific they can leave the line blank. Then collect the papers from students, verifying that their names are on the top of the papers.

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

**Mysterious Robbery (12 minutes)**

Tell the students, “10 years ago a robbery happened that was never solved. The police have contacted us to help them solve the cold case. At the time of the crime, a note, written in black pen, was passed to the teller which read “Give me all your money.” The teller handed over the money but kept the note. In the confusion that followed, the robber managed to get away. At the time, there were eight suspects. Each of these suspects was found with a black pen on them (which the police still have). The only other evidence that the police have from the original crime was the note. No fingerprints were found on the note or at the scene of the crime. How could we figure out who wrote this note using the skills and knowledge learned from your experiments?” If students are having trouble generating responses prompt them by asking what they did in their experiments and have students expand on these ideas. Allow students to discover that you can determine the identity of the thief by determining the unique properties of each pen. If you can find a link between the ink on the letter and the ink from one of the pens found on the suspects, then you can identify the robber. Just like the experiments they did, they could take a sample of the ink from the letter and see what happens when it is put in a liquid. Then they can run the same procedure on each of the pens that were found. Comparing the letter ink to the suspects’ pen’s ink will allow them to determine the robber.

Ask students if it would be easier to identify the robber’s pen from a shorter or taller smear? The students should realize the taller the smear the more details they could learn about the dyes used in the pen. This would make it easier to tell the pens apart and identify the robber. Tell the students that the police have suggested several values for different variables that could be used to run the experiment, but they need the students’ help in identifying the best values for the variables. Have students turn to page 24 of their notebooks and fill out the chart together.

Ask students which amount of time would allow the smear to be the tallest. Students should realize that the longer the time in the liquid, the taller the smear. Thus, the “best” choice for time will be 10 minutes. Circle 10 minutes in the example notebook and have students copy this into their own notebook. An example can be seen below.
Now ask students which liquid type would allow the smear to be the tallest. Students should realize that the thinner the liquid, the taller the smear because thick liquids do not travel as far up the paper as the thinner liquids. Student should have experienced this if they tried soap (thick liquid) in comparison to water, vinegar, or rubbing alcohol (thin liquids). Syrup is another thick liquid; therefore, students should be able to predict that it will not be a “good” liquid to choose. From the selections given, water would be the best choice for the tallest smear. Circle water in the example student notebook and have students copy this response into their own notebooks. An example can be seen below.

<table>
<thead>
<tr>
<th>Liquid Type</th>
<th>Water</th>
<th>Soap</th>
<th>Syrup</th>
</tr>
</thead>
<tbody>
<tr>
<td>All would give similar height smears</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Now ask students how much liquid should be used to get the tallest smear. From their experiments, students should have seen the lower the liquid level, the longer it takes for the liquid to reach the dot. This leaves less time for the dot to smear, resulting in a shorter smear height. However, if the liquid level is above the dot, and the dot is soluble in that liquid (smears in that liquid), the dot will start to dissolve into the liquid and will travel down into the liquid instead of up the paper. Therefore, the liquid level should be as close to the dot as possible, without going over the dot. Circle this response in the example notebook and have students copy this into their notebooks. An example can be seen below.

Once students have filled out the table, tell them that the police took their suggestions and ran their experiments. Show students the results of the experiment (page 5, picture packet).
Have students look at the data and come up with a conclusion. Because there are no measurements on the strips, students will have to use observations for data. Therefore, make sure that they use the word “observed” in the data portion of the conclusion. Have students individually fill out the conclusions and then share them with the class. An example conclusion is shown below.

![Image of a conclusion template](image)

**Mixture Discussion (10 minutes)**

Ask students, “What do you think these results imply about composition of the black ink?” Students should respond that black inks are composed of many different colored dyes making them mixtures. Have students fill in question 3.

![Image of a Matter Chart](image)

Make sure that the Matter chart is taped to the board. Ask students if they know what matter is. If they do not, give them the definition (matter is anything that occupies space and has mass). Point to a few objects around the room and ask them if they are matter. These will all be matter. Ask students if energy, ideas, and dreams are matter. Students should say no. Write “matter” in the top box of the chart for question 4 while students copy it into their notebooks.

Ask students if the black ink is matter. Students should respond yes. Tell them that all mixtures are matter and review the definition of a mixture with student (materials made up of two or more substances). Write “mixture” in the bottom left box of the chart for question 4 while students copy it into their notebooks. Give students the example of Lucky Charms and have them give you the parts of the mixture (marshmallows and cereal) and record these on the matter chart. Then have students generate at least one more mixture that can be distinguished by eye (example: trail mix – peanuts, raisins, M&Ms, etc.) and record that mixture and its parts on the matter chart.

Tell students that sometimes you cannot see the individual parts of a mixture, like the ink from the black pens or the air. However, both of these are still mixtures of multiple substances. Have students tell you the substances that make up air (oxygen, carbon dioxide, nitrogen, etc.) and record it on the matter chart. Then have students generate at least one example of a mixture that they cannot tell with their eyes is a mixture (example: soda – water, sugar, dye, carbon dioxide, etc.) and record it and its parts on the matter chart.
Tell students that mixtures can be separated into pure substances. Write “pure substances” in the bottom right box on the chart for question 4 while students copy it into their notebooks. Pure substances are materials that are composed of only one substance, for instance, water. Have students generate two other pure substances (example: sugar, oil, salt, nitrogen, iron, etc.) and record them on the matter chart.

Teacher Note: Pure substances contain two categories: elements and compounds (substances made up of two or more elements). Sometimes students state that water is not a pure substance because it is composed of hydrogen and oxygen. If this happens, tell students that in order to separate the hydrogen and oxygen in water you would have to break chemical bonds, and this would change the water into something else. If you had hydrogen atoms and oxygen atoms and you mixed them together, they would not form water without a chemical reaction occurring. For things to be a mixture, you have to be able to mix the parts back together to form the original mixture. Compounds can be separated into their elements using chemical properties, but this changes the substance and makes it so that the original substance cannot be reformed unless a chemical reaction occurs. Do not go over this with students unless asked.

Tell students that mixtures and pure substances are related because all mixtures can be separated into their pure substances by taking advantage of differences in the physical properties of the substances that make up the mixture. Write “physical property” on the line under “matter” on the chart for question 4 while students copy it into their notebooks.

Tell students that a physical property is a property that can be measured or observed without changing the substance. Then have students tell you what to put in the blanks for question 5 while they copy them into their notebooks.

Ask students what physical properties they could use if they wanted to separate the Lucky Charms. Or, in other words, what could you measure or observe about Lucky Charms that you could use to separate it into its parts? Student might generate the following: color, shape/size, texture, etc. As students generate these, record them under “physical property” on the chart for question 4. It is ok if not all of the blanks are filled. More physical properties can be added as students identify them as the activity goes on.

Ask students, “What are physical properties of the black ink and paper?” Record these answers for question 6 and 7. If they generate a physical property that is not on the chart in question 4 (example: liquid), change it to a general physical property type (example: state of matter), and add it to the chart. If there is not enough room, put it in the margins beside the chart. Student do not need to write in the physical properties in the margins in their notebook.
Ask the students if black ink is a mixture or a pure substance? (mixture) Ask students if we separated the ink into its parts? (yes) Ask students if all physical properties can be used to separate mixtures (question 8). Lead students to understand that even though we know that the ink is made up of red, blue, etc. dyes, this will not help us separate the ink. Circle “no” for question 8 and have students do the same in their notebooks.

Ask students how we were able to separate out the different dye colors. By the end of the conversation make sure that students understand that in order for the dot to smear out into its different dye parts, the paper had to be put into a liquid. Ask students why some dye colors traveled up the paper farther than others. By the end of the conversation make sure that students understand that the dyes that traveled up the paper farthest were more attracted to the liquid than the paper, and the dyes that moved very little were more attracted to the paper than the water. Tell students that the types of physical properties that were used to separate the black ink were the attraction to the paper and the attraction to the water. Record these in question 9 while students write them in their notebooks.

Show students page 1 of the picture packet, a strip from Day 1 of the module and have students use it to answer questions 10 and 11. They should realize that since the blue ink is high on the paper, it is attracted more to the liquid than the paper. Since the yellow ink did not move, it is attracted more to the paper than to the liquid.

Separating Mixtures/Physical Properties (7 minutes)

Hold up the bottle of water and sand. Ask the students if the bottle contains a mixture or a pure substance and why. They should be able to see that the bottle contains two different substances, therefore, it is a mixture. Ask them what physical property they might use to separate the two substances.
Students should notice that the water is a liquid and the sand is a solid. Write “liquid” under water and “solid” under sand on the chart for question 12. Ask students if this property would be useful in separating the mixture and have students circle yes or no. Have students generate two more physical properties (example: color and mass) and the value for both water and sand (example: clear and brown) and record the values in the chart. Then have students identify if the property would be useful in separating the mixture. If they generate physical properties that are not on the list in question 4, add them to the list.

<table>
<thead>
<tr>
<th>Mixture</th>
<th>List 3 Physical Properties of each part of the mixture</th>
<th>Helpful in Separating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>liquid brown</td>
<td></td>
</tr>
<tr>
<td>Sand</td>
<td>solid brown</td>
<td></td>
</tr>
</tbody>
</table>

Have students determine if each component of the mixture is a pure substance. Students should understand that water is composed of only one material (water), so it is a pure substance. Circle yes. Students should also understand that sand can be made up of many different types of rock fragments (this can be seen by all the grains of sand being different colors), therefore, it would take additional work to separate the sand into its pure substances. Circle no.

**Pure Substances (16 minutes)**

Tell students that in addition to using physical properties to separate mixtures, physical properties can be used to identify pure substances. Have students fill in question 13.

Pass out the labeled pure-substance bags. These four bags contain a single pure substance (sugar, salt, baking soda, or corn starch). Tell students they will be given a few minutes to identify physical properties of each of the pure substances, which they should record in their notebooks. Tell them that they may touch and observe the bags, but they may not open any of the small bags. Once they have written down the physical properties, you will take away the labeled bags and give them four bags that are lettered A-D. They will then need to determine the identity of the pure substance based off their notes. Give students ~5 minutes to examine and write down the physical properties of the labeled substance, then remove the bags. Hand out the letter bags and have them determine what the unknown substances are:

- Bag A = Baking Soda
- Bag B = Sugar
- Bag C = Salt
- Bag D = Corn Starch

Once students have completed the activity, ask them to share their answer for each lettered bag. Also, ask them what physical property was most helpful in identifying the substance. Once a student has shared, poll the class using thumbs up/thumbs down for agree/disagree with the student. If a student disagrees, have them explain why and share what physical property they used to identify the substance. Collect the bags from the students.
Tell the students that they have taught you a lot about mixtures. You now know that black ink is a mixture and that you can use physical properties (such as the attraction of the ink to the paper) to separate the black ink into its parts. In addition, physical properties can also be used to describe pure substances.

**Content Assessment:**
(10 minutes – Full Class – SciTrek Lead):

Tell students to close their notebooks and place them in the corner of their desk. Pass out the Content Assessment to the students. Tell students to write their name, teacher’s name, and date on the top of their paper. During the assessment, remind students to work by themselves. Read each of the content questions to the students and have them select/fill out the correct answer. When students are finished, collect the assessments and verify that they have written their name on the assessment.

Tell students that they can keep their notebooks and that you have enjoyed learning science with them, and that you hope they continue to see themselves as scientists and exploring the world around them.

**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 collected.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Trial A</th>
<th>Trial B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cloth Type</td>
<td>Water</td>
<td>Soap</td>
</tr>
<tr>
<td>Liquid Volume</td>
<td>1 mL</td>
<td></td>
</tr>
<tr>
<td>Agee Type</td>
<td>Original</td>
<td></td>
</tr>
<tr>
<td>Pan Color</td>
<td>Red</td>
<td></td>
</tr>
<tr>
<td>Pan Size</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data</td>
<td>Trial A</td>
<td>Trial B</td>
</tr>
<tr>
<td>Linear Height</td>
<td>4 cm</td>
<td>6.5 cm</td>
</tr>
<tr>
<td>Liquid Height</td>
<td>8 cm</td>
<td>3 cm</td>
</tr>
<tr>
<td>Other:</td>
<td>Green</td>
<td>Blue</td>
</tr>
<tr>
<td></td>
<td>Blue</td>
<td>Red</td>
</tr>
<tr>
<td></td>
<td>Pink</td>
<td>Orange</td>
</tr>
</tbody>
</table>

Can this group make a claim/conclusion?

- Yes
- No
- I Don't Know

- Step 1:  
  - the height of the smear in Trial A was 2 cm and the height of the smear in Trial B was 4 cm.
  - Complete: Correct Claim

- Step 2:  
  - the type of liquid does not affect the smear height.
  - Complete: Correct Claim

- Step 3:  
  - with a lot of liquid, the color type results in a shorter smear height.
  - Complete: Correct Claim

- Step 4:  
  - the color of the pan affects the smear height.
  - Complete: Correct Claim

- Step 5:  
  - the liquid type affects the smear height.
  - Complete: Correct Claim

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

- **The thicker liquid (Soap) had a 6.5 cm high smear and the thinner liquid (Water) had a 4 cm high smear.**