Throughout the guide, teaching tips are in red.

Activity Description & Estimated Class Time

This lesson consists of six 50-minute sessions that investigate the interactions of light and matter. In the first two sessions, students measure changes in temperatures of differently colored cards placed in direct sunlight. In the third and fourth sessions, students measure the amount of light the cards reflect. Students are challenged to compare data sets from the first and second sessions to find a pattern in the reflectance and heating data. In the fifth and sixth sessions, students experiment with colored transparent plastic to gain understanding of materials that let some colors of light pass through while absorbing others. The lesson culminates with a challenge to write a secret message that can only be read when viewed through a piece of colored plastic.

Objectives

Students will develop an understanding that light is a form of energy, some of which we see, and some of which we do not. Students will demonstrate knowledge and understanding by:

- using materials to measurably absorb light;
- using materials to measurably reflect light;
- comparing absorption and reflection in the same materials; and
- using materials to manipulate light to change colors.

Correlations to NC Science Standards

6.P.3.2 *Explain the effects of electromagnetic waves on various materials to include absorption, scattering, and change in temperature.*

Correlations to the Common Core State Standards for Mathematics

Students generate their own graphs in the first of these lessons. That activity is set aside and labeled as a mathematics extension. Under the common core mathematics standards, grade 6 students evaluate data in a number of ways, including statistically and graphically. As a number of common core math standards apply, we have not specified a standard, but left it to teachers to decide which skills to work with here.

Brief Science Background

Electromagnetic waves are comprised of both electricity and magnetism. Like all waves, they can vibrate at different rates, and their characteristics depend on how quickly or slowly they vibrate. They do not look like waves on water or a string, and in fact, most do not look like anything at all because they vibrate too fast or too slow to interact with our eyes. Even though we can't see them, we know they exist because they interact with matter. When they do, both the electromagnetic waves and the matter are affected. Depending on the type of matter, electromagnetic waves may be reflected, absorbed, scattered, refracted (as with a prism), or they might simply pass through. Light

Brief Science Background, cont

waves are examples of one type of electromagnetic wave. When they are absorbed, they may heat the matter that absorbs them, or cause a chemical reaction, such as when light strikes a green leaf and causes the reactions that support plant life (photosynthesis). Other types of electromagnetic waves create an electrical current in conductors. These are examples of ways that electromagnetic waves transfer energy.

Part 1 — Soaking Up Some Rays – Two 50-minute Sessions

Materials

Materials for the whole class

- 15 digital thermometers
- several rolls transparent tape
- 16 envelopes
- class set of color sample cards (orange, brown, white, light green, yellow, red, and blue) to be cut into 1" x 3" strips.
- 16 copies of BLM 2
- 15 copies of BLM 3
- some means of timing in 30-second intervals (provided by teacher)
- graph paper
- optional if no shade: umbrellas (provided by teacher and students)

Materials for pairs of students

- 1 digital thermometer
- transparent tape
- an envelope containing orange, brown, white, light green, yellow, red, and blue 1" x 3" color sample strips
- 1 copy each of BLM 2 and BLM 3
- 2 sheets of graph paper
- 2 student science notebooks (provided by teacher)

Preparation

1. This activity requires an outdoor location, a sunny day, relatively still air, and nearby shade. If there is no convenient shade, provide umbrellas for shade.
2. Cut the color sample cards to make as many 1" x 3" strips as you can from each card. Students will fold the 1" x 3" strips in half lengthwise and tape the sides as shown in BLM 1. When folded in this way, a sleeve fits over the thermometer and in the reflectance meter sample holder. Place 7 different color strips (folded and taped or not) in envelopes, one envelope per team.
3. Have thermometers, tape, color sample sets, and envelopes arranged so that students can pick these up.

Procedure

1. Start by asking, “When light hits a surface, what can happen to the light, and what can happen to the surface it hits?” **No direct teaching here. Accept all answers.** After brief discussion, explain that the class will try to find some things out about this.

2. Give out the envelopes with color samples. Ask a student from each pair to take an orange, a black, and a white color sample from their envelope.

3. Say, “We will go outside to investigate how light and these color samples interact. Before we go out, I will show you what each team will do.” Give a volunteer team a copy of BLM 2 and project BLM 2 for the class. Walk the volunteer pair through the following for the class:

   a. Say “We will start outdoors in the shade. When we are outdoors, keep everything in the shade until we start timing and put everything back in the shade when we finish timing.”

   b. Ask the volunteer team (in the shade) to set a thermometer to º F, place the orange sleeve on the thermometer, and call out the temperature when the reading stops changing. Ask them to record this temperature on BLM 2 under the “Starting Temp” column for the orange color.

   c. Say to the whole class, “When I say ‘START,’ move into the sun. I will begin timing and call time after 3 minutes. When I call time, record the temperature in the Final Temp column of BLM 2 and turn off your thermometer. Then, calculate the change in temperature. When we go outdoors, we will do this three times with three different colors.”

4. When all teams have their materials, go outside to a shady location. Remind students to stay in the shade while they prepare thermometers, put the orange sleeves over the thermometer tips and record their starting temperatures. When ready, call “start” and follow the procedure above.

5. Have students return to the shade and remove the orange sleeves from their thermometers. Ask each team to pick the color they think will get *hotter* than the orange sample when held in the sun and record it on the top part BLM 2. Follow the above procedure with the new color. **Be sure students turn the thermometers off and on before testing the new colors. The thermometers time out after a few minutes and this resets them.**

6. Ask each team to pick a color they think will stay *cooler* than the orange sample when held in the sun, and record it on the top part of BLM 2. Repeat the above procedure.

7. Bring the class inside. Ask, “What happened to the temperature of the orange sample when it was in the sun? What are some possible explanations for what happened?” After they share ideas, explain that when light strikes an object such as a piece of paper or a rock, some light energy is “absorbed” in the surface. The absorbed light becomes heat. Therefore, the amount of light absorbed is closely related to the increase in temperature.

8. In shade (or indoors), remind students that they tested colors they thought would either get warmer or stay cooler than the orange sample. Show the four new color samples and list them. Ask students to think about what they

Part 1 cont.

discovered regarding temperatures of the orange, black, and white samples, and then, in the bottom chart on the BLM 2 data sheet, predict the order of all seven colors, from highest temperature gain to lowest temperature gain. Wait for all teams to record their predictions before going on.

9. Assign each team one of the seven color samples, making sure that each color is assigned to at least one team. Have teams assigned to one of the four new colors make their corresponding thermometer sleeves.

10. Project BLM 3 so that students can see the information they will collect. Point out that the procedure will be the same as before, but this time, teams will record temperatures every 30 seconds for 3 minutes (at 30, 60, 90, 120, 150, and 180 seconds) as you call time.

11. Take the class outside to test their samples.

12. Bring the class inside. Ask each team to calculate the temperature change between the final and starting temperatures and record it on BLM 3. Compile the class results and post or project them for all to see. (For two teams with the same color, average the results). Have students use the class data to complete the bottom section of BLM 2.

13. Ask the class to examine the data for all colors. In particular, ask students to compare their predictions to the experimental results. Were they surprised by any of the results? Ask students what they notice, for example, which colors warmed most and least, whether those that warmed most had anything in common. Discuss observations.

Content Wrap-Up

At this point, simply check for understanding. More formal teaching and a guided practice will occur after the next activity.

1. Give the following challenge: “Write two or three sentences that use the terms color, absorption, sunlight and heat to explain our results.” **This writing could be in notebooks or on separate paper.** Discuss their responses if necessary.

2. Point out that even though all the colors were exposed to the same amount of light for the same amount of time, all colors did not heat up by the same amount. Ask the class what they can infer from this. **All colors did not absorb the same amount of light.** Ask what they think might be happening to the light that is not absorbed? Accept all answers.

Math Extension

1. Have students individually use the data their team entered on BLM 3 to graph the change in temperature over time. The most informative and easiest graph to make shows change in temperature from the starting temperature at each time interval (rather than actual temperature at each time interval).

Part 1 cont.

2. Point out to the class that in order to make the graphs easy to compare, each student should use the same grid and the same axes with the same range. Ask the class to come up with a way to make the axes the same for every student. If they have trouble with this, discuss the range of the temperature data.

3. Remind students to include a title on their graph, which should indicate the color of their sample. Post all students' graphs. Discuss and compare what the graphs show in terms of *rates* of heating.

4. Combine all teams' data in one Excel spreadsheet and make a multiple-line color-coded graph so that data from the whole class appears one sheet. Often, a breeze or a passing cloud causes a change in slope during a 30-second interval. If so, all of the graph lines will track together, each in their own way. This provides a good opportunity to interpret the graphs.

Part 2 — Reflection – Two 50-minute Sessions

Materials

Materials for the whole class

- 15 8" x 8" x 1.5" pizza boxes, unassembled
- 15 black punch cards to make 15 sets of light baffles, solar cell stands, and sample retainers
- several staplers (supplied by the teacher)
- 15 solar cells with red and black banana plug leads
- 15 multimeters
- a bag of small rubber bands
- several transparent tape dispensers
- 15 flashlights
- 15 color sample sets, 7 colors each, (folded sleeves from previous lesson)
- 15 envelopes
- BLM 11 to project
- 15 copies of BLM 12

Materials for teams of two

- 1 reflectance measuring device (see Preparation, below)
- 1 multimeter
- 1 flashlight
- 1 7-color sample set in an envelope
- 1 copy of BLM 12
- student notebooks (provided by teacher)

CIBL

Part 2 cont.

An efficient way to prepare the reflectance measuring devices is to get 3 or 4 students to help outside of class time. If you assemble a prototype for your helpers, 5 people can make 15 boxes in about 30 minutes. Once made, these setups can be re-used for all classes.

Preparation

1. Refer to **BLM 5** (photo of a completed setup) as you assemble a prototype reflectance measuring device:

   a. Punch out the items listed below and sort them into three stacks:
      - light baffle punch-outs
      - solar cell stand punch-outs
      - sample holder flaps

   b. Ask your helpers to assemble the pizza boxes.

   c. Staple in the sample holder flaps so that one of them touches but does not cover the slot used for the pizza box tab, as shown in BLM 6. The flaps should be about ¾ inch apart. Be sure there is room to insert a folded color sample sleeve between the stapled areas of the flaps.

   d. Fold the solar cell stand so that the triangle (base of the stand) makes a right angle with the rectangle (see BLM 7). Attach the solar cell to the upright rectangular portion of the solar cell holder with a rubber band. The solar cell goes on the side opposite the triangular base (BLM 8).

   e. Thread the solar cell wires through the tab slot near the corner of the box, as shown in BLMs 5 and 9. Once the wires are through, tape the solar cell assembly to the bottom of the box (BLM 9) with the edges of the triangular base parallel to the sides of the box.

   f. Tape the upright section of the light baffle (the part with the slit) to the wall of the box (BLM 10). The upright portion should just touch the right edge of the right-hand sample holder flap. With that in place, tape the light baffle to the floor of the box (BLM 10).

2. Put out 15 of these setups for students to pick up.

3. Set out the flashlights, multimeters, and solar cells.

4. Set out an envelope of 7 color sample sleeves for each team.

5. Be ready to *show* BLM 11 for all to see.

6. Make 1 copy of BLM 12 for each team.

Part 2 cont.

Procedure

1. Remind students of the question asked at the end of the last class: what happens to the light that does not get absorbed? Explain that you have some measuring devices that can be used to find out a little more about this.

2. Ask students to charge the flashlights for 30 seconds, turn them on, and place them in the box so that only one LED is positioned in front of the slit to make the brightest possible circle of light between the sample holder flaps. Ask teams to leave flashlights in place and turn them off.

3. Project BLM 11 and ask students to put the solar cell plugs in the multimeter as shown, matching wire color to hole color. Instruct students to set the multimeter dials to the 200m position as shown. The meter should read above zero. Ask teams to close the box and press down the lid. With the box closed and flashlights off, the reading should be zero. If not, check for light leaks. Nearly all light leaks disappear when the lid is pressed down carefully. If not, check the assembly of the box.

4. Ask teams to turn on flashlights, pick them up, shine them directly on the solar cell, and record the multimeter reading in notebooks. Ask "What does the meter measure?" **The amount of light reaching on the solar cell.**

5. Ask teams to slide the orange color sample into the sample holder flaps and put the flashlight in place with one LED shining directly through the slit to make a bright circle on the sample. Ask them to close the lids and take a reading. **It is not necessary to record the reading at this time.** Ask "How does this reading compare to when you shined the light directly on the solar cell?" Ask "What does the meter measure?" **The amount of light reaching the solar cell. It should be a lower number than when the flashlight shined directly on the solar cell.** This reading has no units such as lumens, a unit of light. The number on the multimeter is only a way to compare different amounts of light.

6. Ask students to open the pizza box lid and turn off the flashlights and multimeters. Ask them to view their setup from above and use a finger to trace the path of light from the flashlight to the solar cell.

7. Ask each team to turn on the flashlight and multimeter, close the lid, take a reading for the orange sample, and record it on BLM 12. Remind them that this number represents the amount of light reaching the solar cell.

8. Remind students that in the previous lesson each team chose a color they thought would get hotter than orange. Ask each team to pick a color that got hotter than orange and write it in the appropriate place on BLM 12. Ask teams to predict whether that color will give a larger or smaller reading than orange. Before testing the sample, ask them discuss their reasons and write them in their notebooks. **Students will likely predict the number to be greater than the number for orange.**

9. Ask students test their predictions, and write their multimeter readings on BLM 12 under "Amount of Light Measurement." **These numbers will likely be less than what they expect. The class will discuss this later.**

10. Say, "In the previous lesson, you predicted a color that would heat up less than orange." Ask teams to identify that color on BLM 12 and predict whether it will produce a larger or smaller light measurement than orange.

Part 2 cont.

11. Ask teams to test their predictions and record results on BLM 12.

12. Lead a whole-class discussion about the following ideas: When light strikes the color sample, it is either absorbed or reflected. Light that bounces off of something is called “reflected” light. The box measures reflected light. The thermometers measured absorbed light. Use the information we gathered in both this lesson and the previous one to account for the light readings we just obtained. **Students should begin to understand that if a sample absorbs more light, it reflects less light, and vice-versa.** End the discussion by projecting or writing the sentences below on the board and asking students to complete them in their notebooks:

A color sample that heats up more in the sun reflects ________light.

A color sample that heats up less in the sun reflects _________light.

13. Say, “We now have a theory about absorbing and reflecting light. Use the theory to order the colors in the bottom part of BLM 12, from those you think will reflect the most light at the top to those you think will reflect the least light at the bottom. After your team makes its predictions, use the light measuring box to test all of the colors. That way you will test the theory.” WHEN STUDENTS FINISH, BE SURE THEY TURN OFF FLASHLIGHTS AND MULTIMETERS. (Leaving either one on ruins the batteries).

Wrap-Up

1. Hold a class discussion comparing the class results to the theory.

2. Ask students which colors from the sample set would be best to wear on a hot summer day.

3. Say that a group of people are playing flashlight tag at night. They can wear any of the seven colors from the sample set. Which color would be best to wear to avoid getting tagged? Ask for reasons and evidence to back up student responses. **The color that reflects the least light would be best. That is the color with the lowest light reading.**

Part 2 cont.

Guided Practice

Ask students to write responses in notebooks. This guided practice covers both Part 1, “Soaking Up Some Rays,” and Part 2, “Reflection.” Discuss all answers, especially “wrong” ones, and ask students to explain why they are wrong.

1. Complete the following sentence with the correct response: The amount of light that a material reflects

   a. is less than the amount of light that is absorbed.
   b. is a property of the material that is exposed to the light.
   c. is based on the weight of material exposed to light.
   d. is equal to the amount of light that is absorbed.

Provide a reason for your answer:______________________________________

____

2. Which of the following materials reflects more light?

   a. something that is very light colored, close to white
   b. something that is an intense, deep color, such as deep red
   c. something that is transparent, such as glass
   d. something that is very dark colored, close to black

Provide a reason for your answer:______________________________________

____

3. Complete the following sentence with the correct response: A material that does not reflect much light

   a. appears to be very bright, even in dim light.
   b. absorbs very little light that strikes it.
   c. absorbs much of the light that strikes it.
   d. might not reflect much light now, but could reflect more light later on.

Provide a reason for your answer:______________________________________

____

Part 2 cont.

4. Complete the following sentence with the correct response: The light that strikes a material

   a. is all reflected.
   b. is usually both reflected and absorbed.
   c. is all absorbed.
   d. is all converted to heat.

Provide a reason for your answer:__________________________________

____

5. Complete the following sentence with the correct response: When more light is reflected,

   a. more is absorbed.
   b. none is absorbed.
   c. all of the light is absorbed.
   d. less is absorbed.

Provide a reason for your answer:__________________________________

____

Answer Key

Discuss all of the answer choices, especially “wrong” ones, and ask students to explain why they are wrong.

1. b. the amount of light that a material reflects is a property of the material. Only the surface of an object affects how much light is reflected. The interior of the object does not matter with regard to reflection. a, c, and d are all wrong for the same reason: the amount of light reflected can be more than, less than, or equal to the amount absorbed.

2. a. something that is light colored (close to white) reflects more light. Deep or intense colors do not necessarily reflect more. Transparent things are not very reflective because light goes through them. Dark colored materials absorb more light and reflect less.

3. c. Materials that reflect less light absorb more of the light that strikes them. These materials do not appear bright. They do, however, always reflect the same amount. This does not vary over time because the amount of light they reflect is a property of the material on the surface.

4. b. The light that strikes a material is usually both reflected and absorbed. Students saw this in their data. It is rarely all reflected or all absorbed. The absorbed light turns into heat.

Part 2 cont.

5) d. The more light that is reflected, the less is absorbed. In the cases the class investigated, a certain amount of light struck each of the color samples. Some of that light was reflected and some was absorbed. If a color reflected more of the light, less remained that could be absorbed. Likewise, if a color reflected less of the light, it meant that more could be absorbed.

Part 3 — Secret Color Message – Two 50-minute Sessions

Materials

Materials for the whole class

- either 15 copies of BLM 13 or the ability to project it
- 30 sheets of paper (provided by teacher)
- 15 sets of 6 colors of transparent plastic: red, green, blue, cyan, magenta, and yellow
- 15 sets of colored pencils

Materials for groups of 2 students

- 2 sheets of white paper
- a set of colored pencils
- 1 set of 6 transparent color filters: red, green, blue, cyan, magenta, and yellow
- 1 copy of BLM 13 or the ability to see it projected.

Preparation

Assemble envelopes containing 6 colors of transparent plastic, one for each pair of students. Be ready to project BLM 1.

Procedure

Start by asking students what they know about light so far. Remind them of previous lessons about the composition of white light, absorption, and reflection. Let them know that in this activity they will investigate another way that light interacts with different materials.

1. Pass out the sets of transparent plastic, have students look through them, and ask them to find three things that appear to change when viewed through the colored pieces. Ask them to describe what changed.

2. Project the first secret message example on BLM 13. Challenge the class to find which one of the colored plastic pieces they can look through to see the message. When most students have seen the message, ask which colored plastic pieces worked.

3. One at a time, show the second and third examples from BLM 13. Repeat the process in steps 2 and 3.

Part 3 cont.

4. Project all three examples, one at a time, and ask students for ideas about how the colored plastic makes messages readable.

   - Ask students if they know of other transparent materials that let light pass through. **Glass, Air, Water** What are some things that seem to color light? **Sunglasses, Colored Glass**
   - Explain that the pieces of colored plastic are certain types of filters. Ask students to describe what a filter does and give some examples. **Filters allow some things to pass through them while other things get caught. Some familiar examples are coffee filters, Brita™-type water filters, oil filters in cars, and air filters in home heating systems.**
   - Inform students that they are using color filters. What could they be filtering? In other words, what passes through and what gets caught? **Some colors of light pass through but other colors do not. They seem to be caught by the filter, so they are absorbed.**

5. Make sure each student has a sheet of white paper and each pair of students has some colored pencils and/or markers. Ask students to make three marks on their paper, using a different color for each mark. Then ask, “How does a colored mark interact with light? **Where there is a colored mark, the place that is marked reflects only that color and absorbs all the other colors.** Next, ask the class, “If a colored mark reflects that color, where is all of the other light going?” **It is absorbed by the mark.**

6. Challenge each individual student to use markers and colored pencils to design a hidden message on the paper, which can only be read by looking at it through a color filter.

7. When students are finished, have each pair trade papers with another pair and try to read the message in white light (without a color filter or using only the uncolored filter). Then have them use the colored filters until they find one that works. *Note:* The message works only if it can be read through a filter, but can’t be read without a filter. Advise students to be prepared to explain how they designed their messages.

Wrap-Up

Project **BLM 14** and explain that the four people in the cartoon are looking at a red mark through blue plastic, and they see the red line as black. However, each one explains what they see differently. Ask each student to pick someone they agree with and someone they disagree with, and come up with arguments for and against. Find students with opposing views and assign them to make their points to each other in small groups.

- White light has all colors and a red mark reflects everything but red. The blue filter takes out all of the blue light, making the mark look black. **The red mark reflects only red, not everything but. The blue filter lets all of the blue light pass through.**
- It looks black because no light, including white light, goes through the blue filter. **Blue light does go through the blue filter. If no light went through, everything would look black.**

Part 3 cont.

- A colored marker reflects the color that we see and absorbs the rest. White light contains all of the colors. A color filter allows one color to pass through and absorbs all other colors. **This is true but it doesn't explain anything. It has all the pieces to address why they see a red line as black, but it doesn't put them together.**
- White light is all colors. Only red light reflects off of the red marker, but a blue filter absorbs red light, so the mark looks black. **This is correct. The only color that the red mark is giving off cannot get through the blue plastic.**

Guided Practice

Guided Practices are similar to typical tests, but require students to reveal their thinking about content. They serve as a practice before a test and should not be graded. They are intended to expose misconceptions *before* an assessment and to provide opportunities for discussion, re-teaching, and for students to justify answers. They are best given as individual assignments without manipulatives used in the activity. In that context, pose the following "test items" to the class. Ask them to write responses in notebooks. You might also ask them to identify the wrong answers and explain why they are wrong.

Choose the response that most correctly completes the following sentences:

1. The colored plastic pieces…

   a.…allow all colors to pass through.

   b.…reflect most colors.

   c.…let all colors pass through except the color of the plastic.

   d.…let only the color of the plastic pass through, and block the rest.

   Provide a reason for your answer:__________________________________

   ____

2. A red mark looks black through a blue filter because…

   a.…the red mark absorbs all the red light and the blue filter absorbs all of the blue light, so no light from the red mark remains to reach your eye.

   b.…the red mark reflects only red light and the blue filter does not let red light through, so no light from the red mark remains to reach your eye.

   c. … the red mark reflects blue light and the blue filter absorbs blue light, so light from the red mark is able to reach your eyes.

   d. …the red mark reflects all colors and the blue filter lets the red light pass through, so light from the red mark is able to reach your eyes.

Part 3 cont.

Answer Key

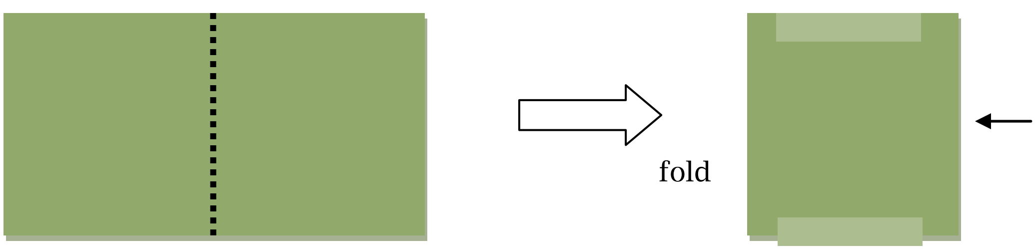
1. The colored plastic pieces (d) let only the color of the plastic pass through and block the rest.

   - a. is wrong because the colored plastic pieces let only their own colors pass through.
   - b. is wrong because the colored plastic pieces reflect only their own colors, not most colors.
   - Answer c. is the opposite of what they do. If they let all colors pass through except the color of the plastic, white objects seen through them would look like every other color combined minus the color of the plastic, which would probably be some shade of brown.

2. The red mark looks black through a blue filter because (b) the red mark reflects only red light and the blue filter does not let red light through, so no light from the red mark remains to reach your eye. If students ask how they see a mark if no light from it reaches their eyes, explain that light reaches their eyes from all around the mark - everywhere there is a color that the filter lets pass. The mark is visible the same way a shadow is visible.

   - a. is wrong because the red mark does not absorb all the red light, and instead reflects it.
   - c. is wrong because the red mark reflects red, not blue, and the filter lets blue pass, not red.
   - d. is wrong because the red mark reflects only red, not all colors, and the blue filter does not let red light pass through.

BLM 1



Fold sample in half lengthwise, color outside

BLM 2

NAMES________________________________Date______________

Color	starting temp °F	final temp °F	change in temp °F
orange			
Color Predicted to Warm More: ____________________________			
Color Predicted to Warm Less: ____________________________			

	Rank Order: Amount of Temperature Change in °F ***Our Prediction***	Amount of Temperature Change in °F ***From Class Results***
1 heats most		
2		
3		
4		
5		
6		
7 heats least		

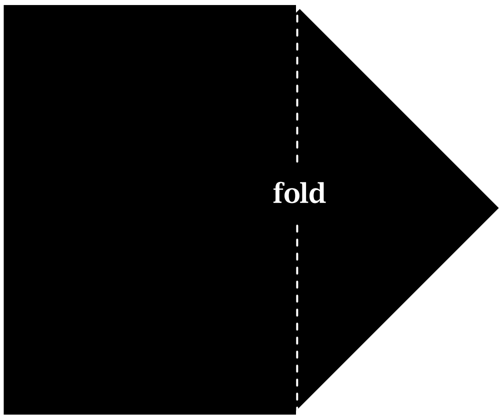
BLM 3

NAMES:______________________________DATE:_________________

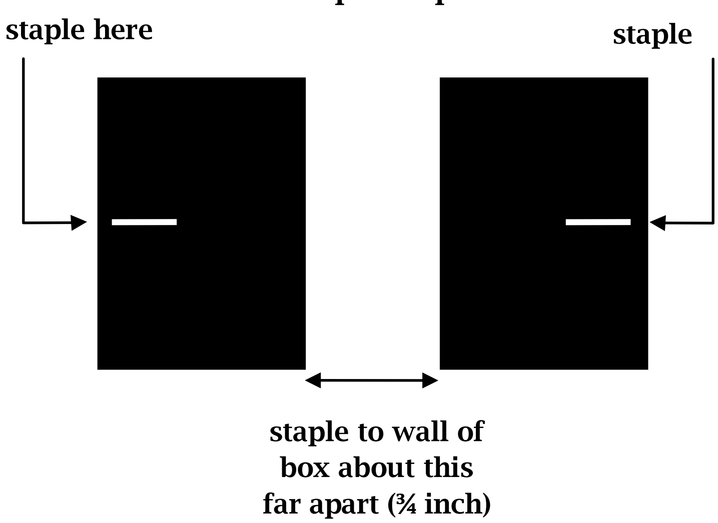
	Your Assigned Color________________________							
	Starting Temperature	30 sec	60 sec	90 sec	120 sec	150 sec	180 sec	Final Change in Temperature
Temperature ˚F								

BLM 4

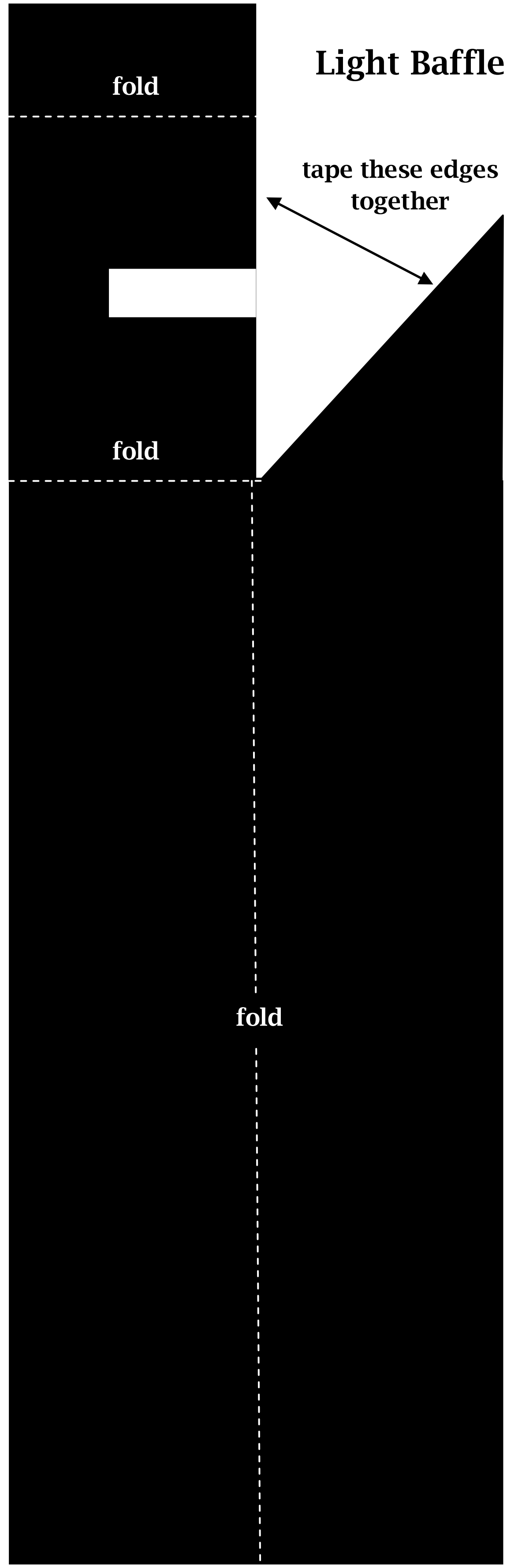
Solar Cell Stand



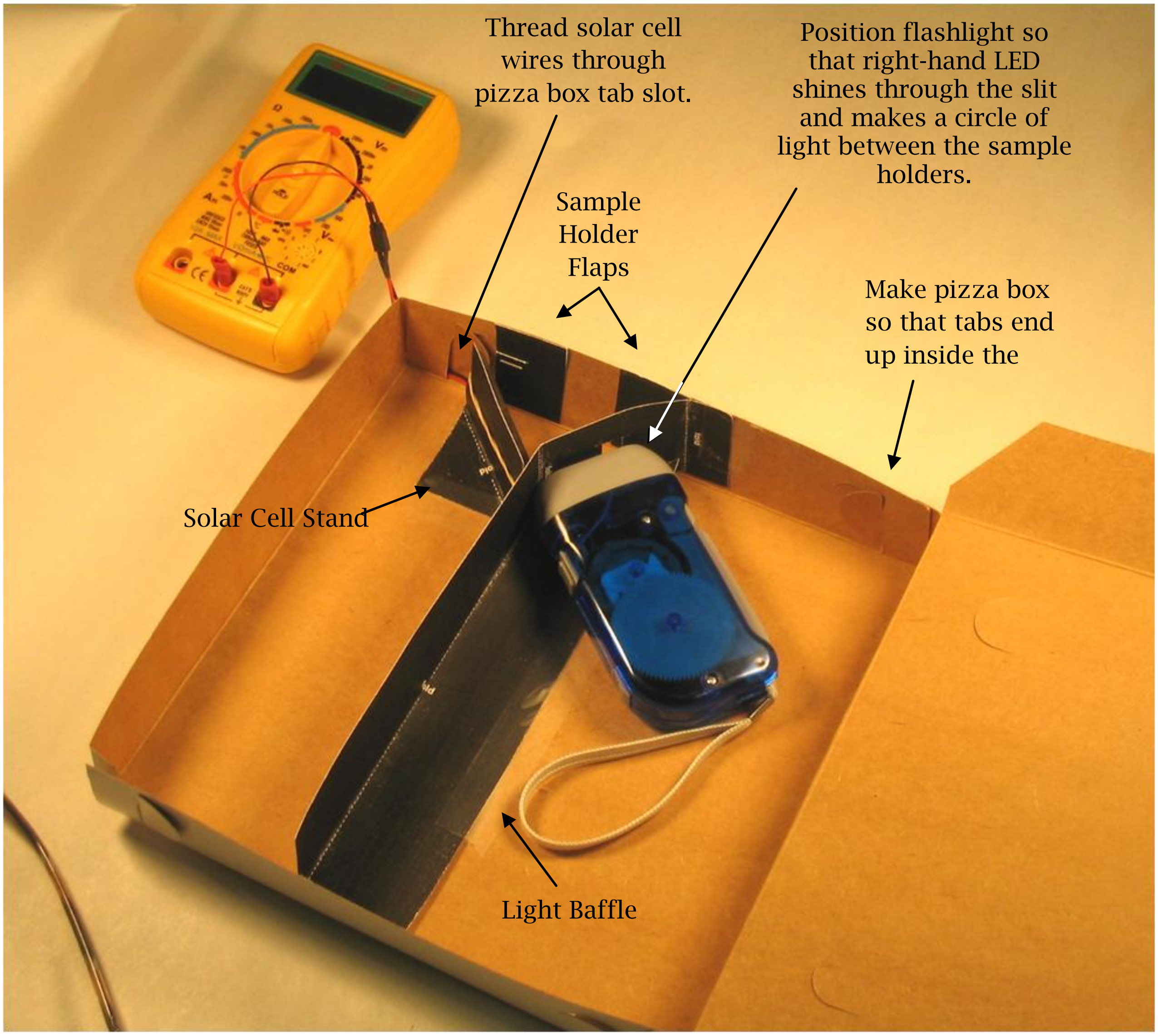
Sample Flaps



Light Baffle

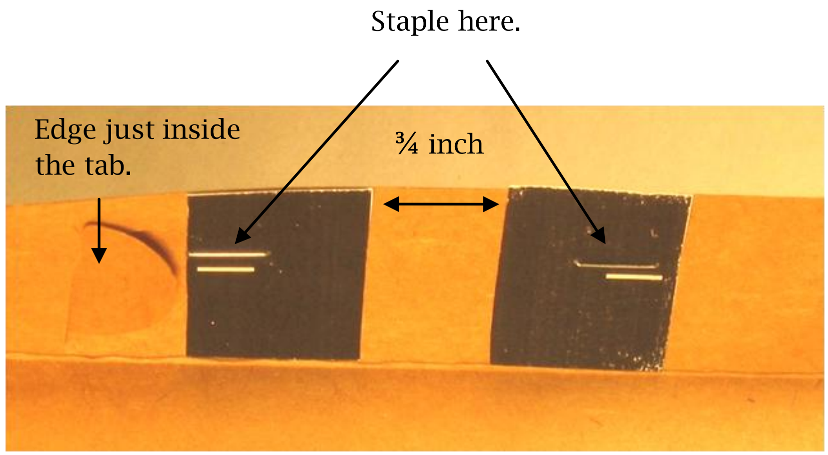


BLM 5


Thread solar cell wires through pizza box tab slot.
Position flashlight so that right-hand LED shines through the slit and makes a circle of light between the sample holders.
Sample Holder Flaps
Make pizza box so that tabs end up inside the
Solar Cell Stand
Light Baffle

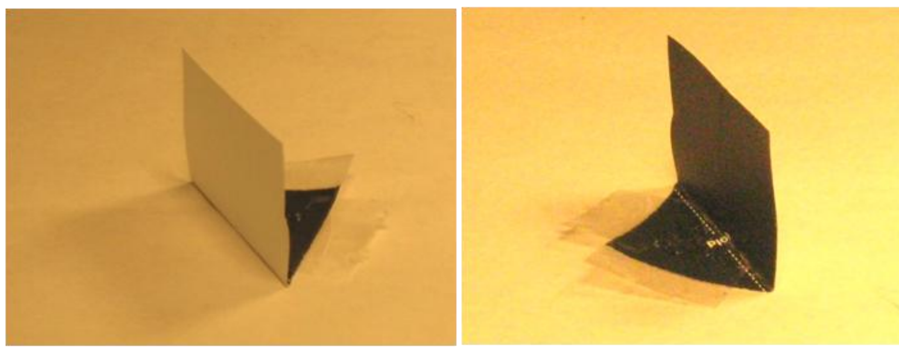
BLM 6

Placing the sample holders



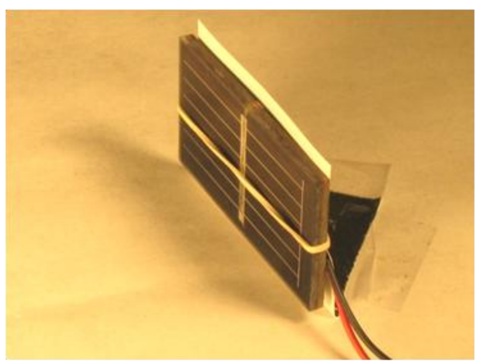
BLM 7

Fold the solar cell stand at a right angle (2 views).



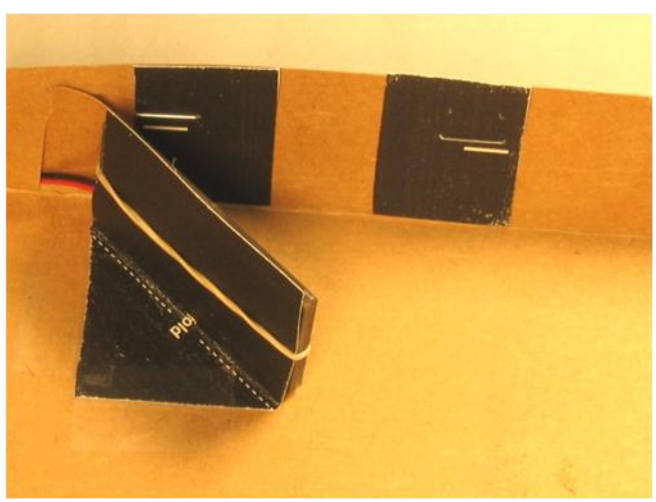
BLM 8

Attach the solar cell to the white side of the stand with a rubber band.



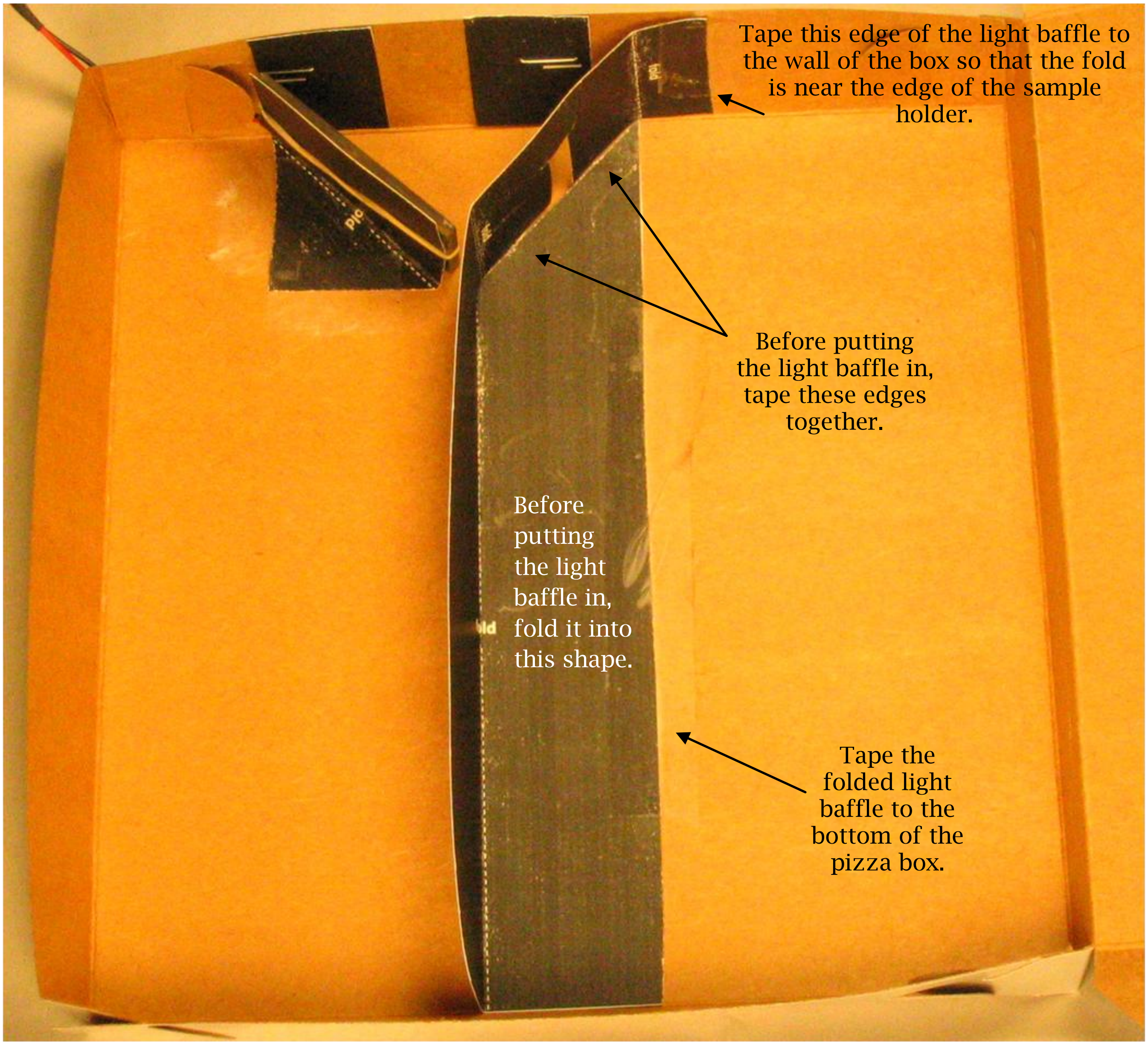
BLM 9

Tape the triangular solar cell stand base to the floor of the pizza box so that the edges of the base are parallel to the walls of the box. The edge of the solar cell should be near the box tab, as shown.



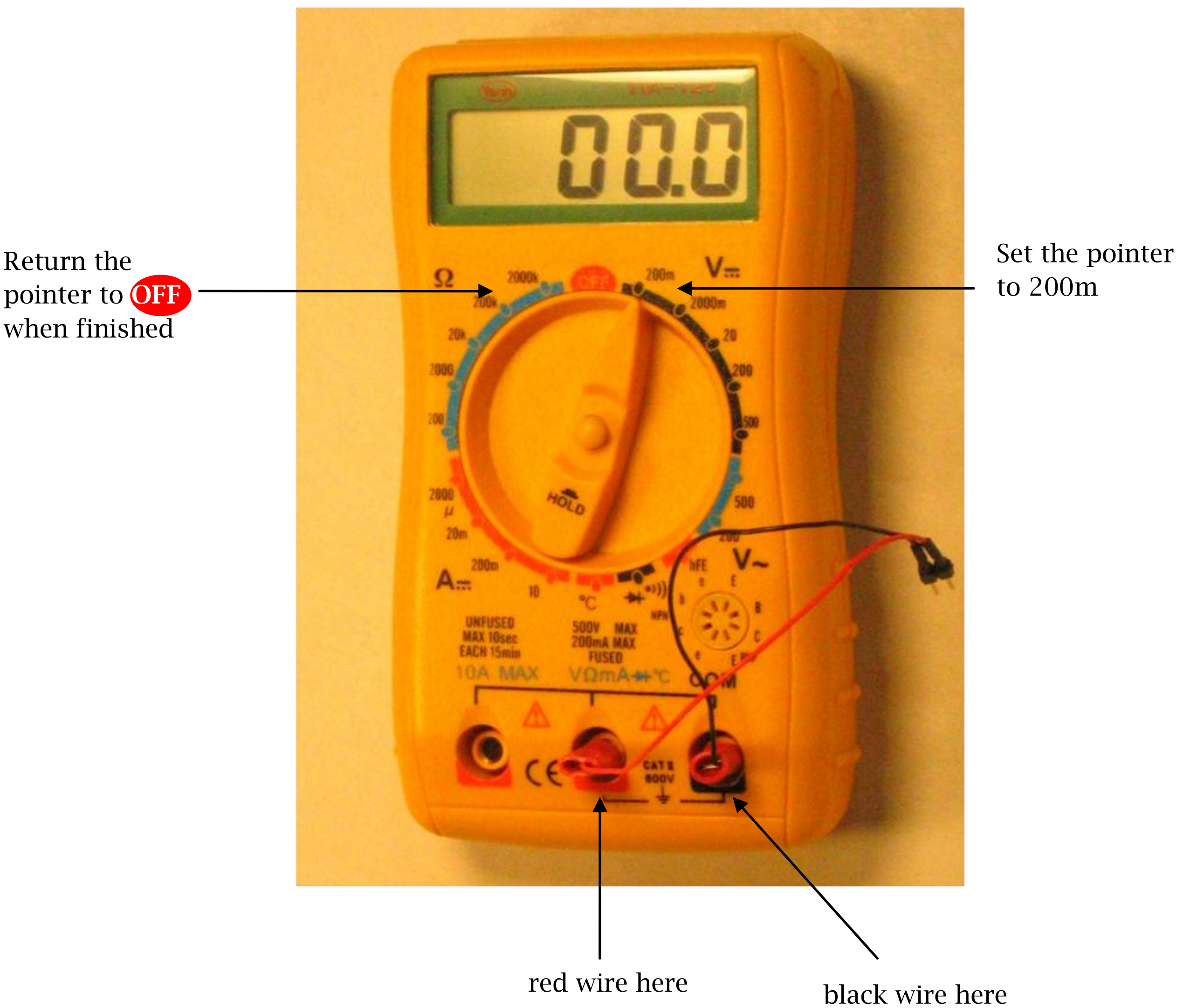
BLM 10

Light box setup



The box should be able to close completely with the top flaps outside of the box. Closed "completely" means no light gets in.

BLM 11


Return the
pointer to OFF
when finished
Set the pointer
to 200m
red wire here
black wire here

BLM 12

Names________________________________ Date____________________

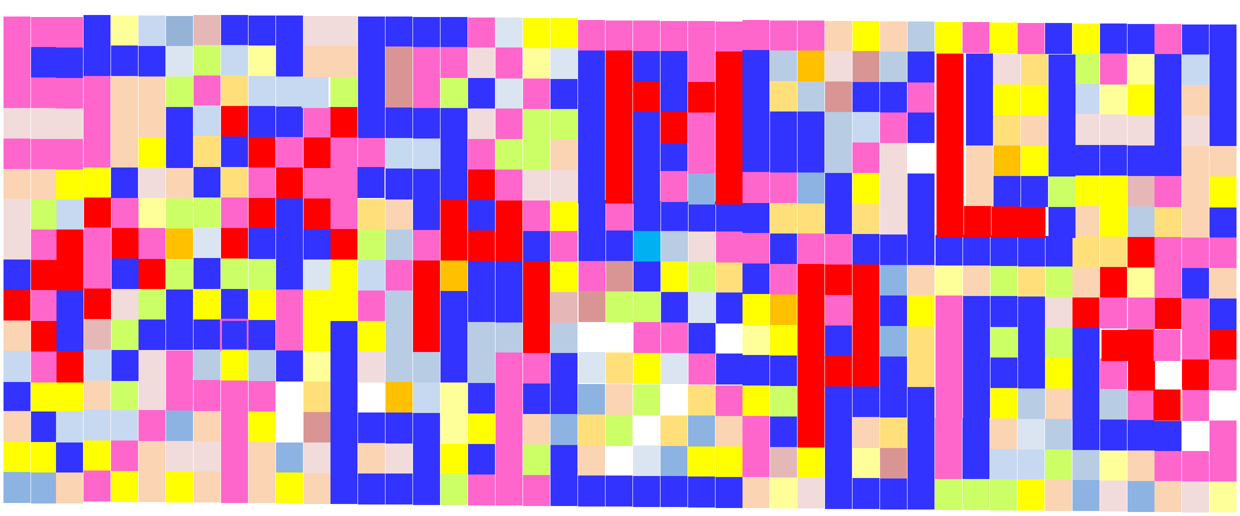
Color	Light Measurement
Orange	
color that got hotter in sunlight	
color that stayed cooler in sunlight	

	Predicted order of light reflected for each color	Class measurements of light reflected for each color
1 reflects most		
2		
3		
4		
5		
6		
7 reflects least		

BLM 13

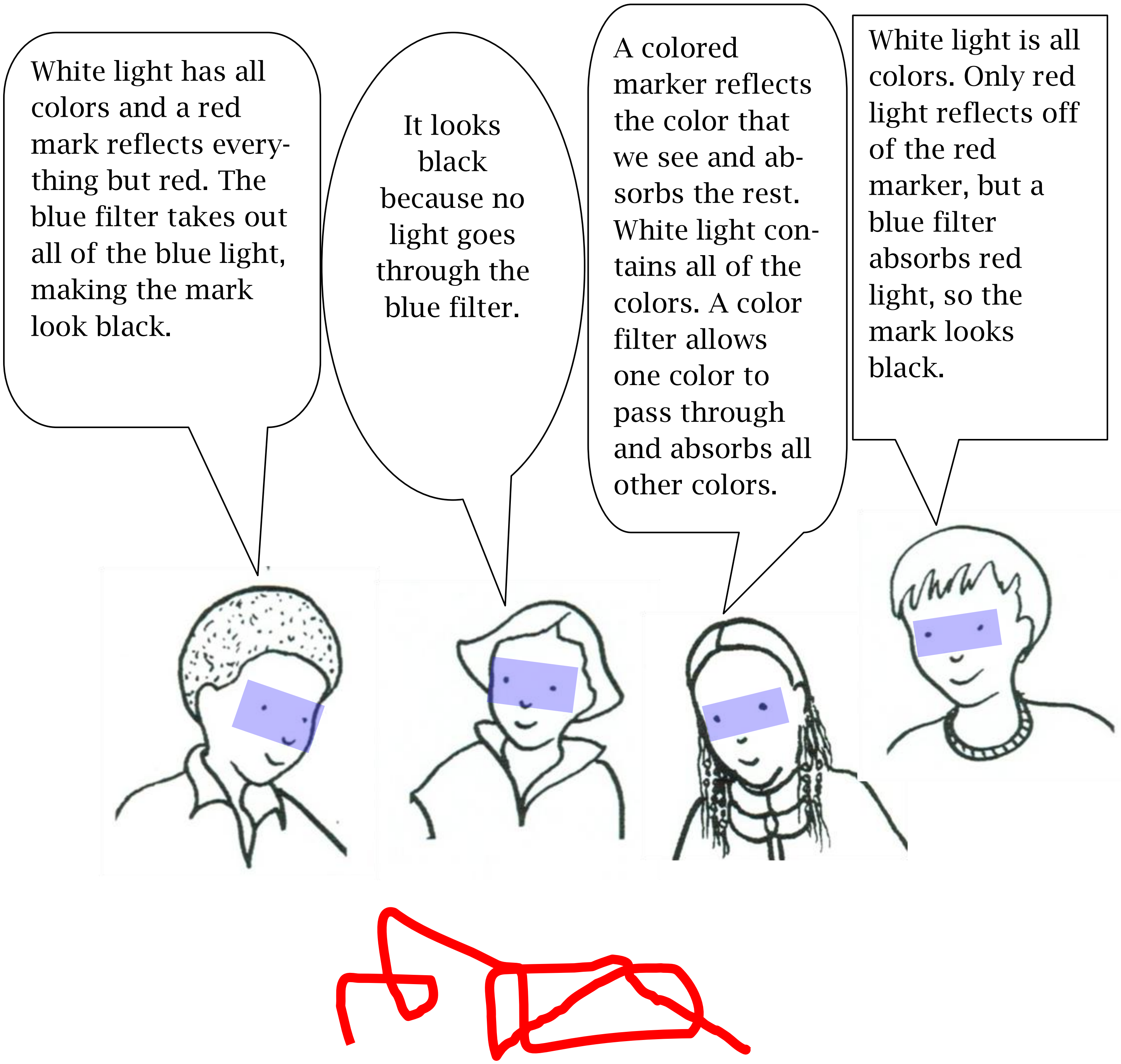
Secret Writing Examples

SEIQBCNROLEPZITMR



BLM 14

Students are looking at a red mark through a blue colored plastic filter. They all see the line as black. Each one has an explanation for why they see it that way. Explain why you agree or disagree with each of them .



Appendix

Common Student Preconceptions About This Topic

Many children ages 10-14 conceive of light as either a source such as a light bulb, an effect such as a patch of light on the ground, or a state such as brightness or dimness. Students tend to think of light as traveling in long, thin, flashing rays. Many also think of light as a medium that transports colors. Students rarely imagine that when they see a non-luminous object such as a piece of paper, they are seeing the light reflected from it. When asked how a lamp brightens a room, about ¾ of children can give no mechanism for this. Similarly, although many understand that light bounces off of mirrors, they do not conceive of it bouncing off of other objects. Even those who accept that light bounces off of opaque objects do not relate this to how we see. Very few children (or adults) grasp the pure abstraction that light is electromagnetic waves with different colors at different frequencies. Instead, colors are seen as discrete things unto themselves, and often as a property of objects rather than as a property of light.