Seeing out of the Corner of Your Eye

FLINN SCIENTIFIC BIO FAX!

Introduction

Stare at an object straight ahead. Can you see anything else out of the “corner of your eye”? Seeing beyond the center of our *visual field* (everything seen while looking straight ahead) is known as *peripheral vision*. Explore the range of your own peripheral vision.

Concepts

- Peripheral vision
- Rods versus cones

Materials

Peripheral vision disk

Sight cards, black and white reading, 1 × 2 , 3–5 per pair of students

Sight cards, color, 1 × 2 , 3–5 per pair of students

Procedure

Read the *Procedure* section completely before beginning the activity.

Part 1. Visual Field: Motion and Reading

Figure 1.

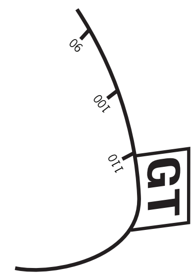


Figure 2.

1. Choose one member of the group to be the subject, and one to be the tester. After the activity has been completed, switch roles.
2. The subject obtains the peripheral vision disk and sits at a desk or table.
3. The subject holds the vision disk horizontally to his or her face, placing his or her nose in the center curve. The disk should be about halfway between the top and the tip of the nose. Use the thumb and forefinger of either hand to hold the disk at the zero point, with the forefinger on the zero (see Figure 1).
4. The tester obtains the reading sight cards and stands in front of the subject.
5. The tester chooses one of the reading sight cards without letting the subject see which one.
6. The tester holds the lower half of the sight card with letters facing inward against the disk before the 110° mark on the subject’s left side, out of the subject’s sight. The vision disk should intersect the card, with the letters above the disk and the tester’s hand below the disk (see Figure 2).
7. The subject focuses on his or her index finger at the zero point (or on an object in the distance that is aligned with the zero point), not moving his or her eyes to the right or left at any time during the test. The tester must watch the subject’s eyes to make sure they stay focused straight ahead. This task may be somewhat difficult for the subject initially, as the eyes may tend to wander, especially as the card becomes easier to distinguish. The subject may try to peek to see if the guesses are correct. (It may help if the tester audibly reminds the subject periodically by saying, “Look straight ahead,” or “Stay focused on your finger.”)
8. If at any time during the test the subject averts his or her eyes from the center gaze and glances toward the card, the tester should choose a different card and place the new card at the same place the original card had reached. Continue the procedure with the new card.
9. The tester slowly and steadily moves the card toward the zero point. As soon as the subject detects the card moving into the field of vision, he or she should say, “Motion.” The tester removes the card at this point (without letting the subject see it), and records the angle at which motion was detected for the left side of the visual field.
10. The tester returns the sight card to the angle on the disk at which it was detected and continues to move the card slowly toward the zero point, reminding the subject to continue gazing straight ahead. When the subject can recognize the two letters and/or numbers on the card, he or she should say the letters/numbers out loud. For example, if the card shows 3T, the subject should say “Three tee.” If correct, the tester records this angle for reading. If the subject does not correctly read the card, the tester does not record the angle and the tester continues to move the card toward the zero point, until the card is read correctly by the subject.
11. Repeat the entire procedure using a different sight card on the subject’s right side. Record the angles for motion and

reading for the right side of the visual field.

12. Switch roles and repeat steps 1–11 using a new sight card.
13. To determine the total visual field, add the left and right angles recorded for motion and for reading, respectively.

Part 2. Visual Field: Motion, Color, Reading, and Shape

14. Repeat steps 1–9 of Part 1, however, substitute color sight cards for the black-and-white reading cards.
15. The tester continues to move the sight card slowly toward the zero point until the subject can recognize the color, the letter or number, or the shape on the card. The subject should announce the detail out loud—for example, "Square," "Three," or "Blue." If correct, the tester pauses and records this angle, labeling with the letter "C" for color, the letter "R" for reading, and the letter "S" for shape. If the subject does not correctly identify a particular detail, the tester continues to move the card toward the zero point, until the detail is announced correctly by the subject.
16. The tester continues to move the sight card toward the zero point until all details of the card—color, reading, and shape (not necessarily in that order)—have been correctly identified.
17. If at any time during the test, the subject averts his eyes from the center gaze, and glances toward the card, the tester should choose a different card and place the new card at the same place the original card had reached. The procedure continues with the new card.
18. Repeat steps 14–17 on the subject's right side, recording the angles for the right side of the visual field. Remember to use a different card.
19. Repeat steps 14–18, switching roles.
20. To determine the total visual field, add the left and right angles of correct identification for each detail—motion, color, reading, and shape.

NGSS Alignment

This laboratory activity relates to the following Next Generation Science Standards (2013):

Disciplinary Core Ideas: Middle School
MS-LS1 From Molecules to Organisms: Structures and Processes
LS1.A: Structure and Function
LS1.D: Information Processing

Disciplinary Core Ideas: High School
HS-LS1 From Molecules to Organisms: Structures and Processes
LS1.A: Structure and Function

Science and Engineering Practices
Developing and using models
Planning and carrying out investigations
Constructing explanations and designing solutions

Crosscutting Concepts
Cause and effect
Systems and System Models
Structure and function

Tips

- This activity is appropriate for a unit on light and color, the nervous system, or the senses.
- Reading sight cards can be made from white index cards or cardstock. Cut the paper into 1 × 2 rectangles, and use a black marker to write two numbers or letters or a combination of a number and letter on the top half of each. See Figure 2. For color sight cards, use a colored marker to make an outline of a shape such as a triangle, square or circle, and write one letter or number in the same color inside each shape. An alternative method would be to test one variable at a time by using colored construction paper to test for color, and draw shapes on white cards to test for shape identification.
- A peripheral vision disk is available from Flinn Scientific (Catalog No. FB0057) or can be made from cardboard or sturdy cardstock (see the References below).
- Student results for color and shape will vary greatly. Color is usually detected before shape. However, this depends on the color and shape being tested. Results of testing show red is easier to detect than blue, and green is hardest to detect. Therefore, the shape of a green-colored object may be discerned before the color.

- The testing done in this activity should not be considered for diagnostic purposes, but students may be interested to know that normal range for peripheral vision is 180º when using both eyes. When using one eye, the total visual field from left to right is normally 150º. A good extension to this activity would be to repeat Part 1 with one eye covered, and again with the other eye covered.
- Research has shown that cell phone usage in an automobile severely limits use of peripheral vision, even for a period of time after the driver has stopped using the phone. Have students discuss the need for peripheral vision while driving, and debate the pros and cons of restricting cell phone usage in cars.
- Some animals have wide peripheral vision to better detect predators. Have students conduct literature research on peripheral vision in animals and compare to humans.
- This activity is available as a student laboratory kit from Flinn Scientific, Catalog No. FB1871. To further explore vision, try the "Visual Perception Activity Stations" kit (Catalog No. FB1872), which investigates depth perception, eye–hand coordination, afterimages, and peripheral vision.

Discussion

The retina, a thin tissue lining the back of the eye, contains specialized nerve cells, called *photoreceptors*, that are sensitive to light. The two different photoreceptors are known as *rods* and *cones*, so named because of their shapes. Rods are more numerous (over 120 million) compared to cones and are more concentrated around the *periphery* (outside edges) of the retina (see Figure 3). They are more sensitive to light than cones and help us see in dim light. Rods are not sensitive to color, however, which is why it is difficult to distinguish colors in a dark room. Rods are very good at detecting motion. A moving object can usually be detected in the peripheral vision before the object can be clearly identified.

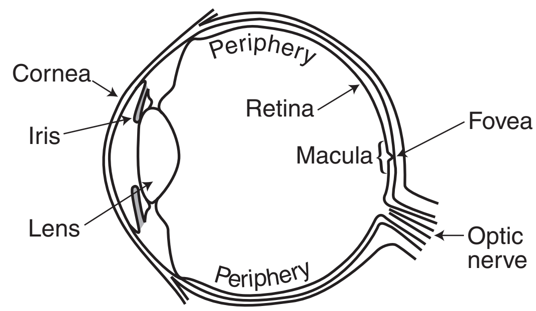


Figure 3.

Although cone receptors are found throughout the retina, the center of the retina, the *macula*, has a much higher density of cones than the periphery. In the center of the macula is the *fovea*—a densely packed area of cones with no rods (see Figure 3). Cones are responsible for color vision. Even though the eye has fewer cone receptors (6–7 million) than rod receptors, cones are vital to our central vision and the ability to see fine details. Cones are used primarily when we read. Try focusing on a letter in the middle of a word in a sentence and see how many other words you can read to the right or left without moving your eyes.

When one looks at something directly, the image is focused on the macula. When something is seen out of the corner of the eye, the image is focused on the periphery of the retina, where more rods and fewer cones are found.

References

"Out of Sight!" *Neuroscience for Kids*, http://faculty.Washington.edu/chudler/neurok.html (accessed January 2015).

Peripheral Vision, http://www.exploratorium.edu/snacks/peripheral_vision/index.html (accessed January 2015).

Materials for *Seeing out of the Corner of Your Eye* are available from Flinn Scientific, Inc.

Catalog No.	Description
FB1871	Peripheral Vision—Super Value Laboratory Kit
FB1872	Visual Perception—Activity-Stations Kit

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.

Earthquakes and Resonance

FLINN SCIENTIFIC EARTH SCIENCE FAX!

Introduction

An earthquake with a magnitude of 8.5 struck Mexico on September 19, 1985. Mexico City, 250 miles from the epicenter, sustained considerable damage. A high percentage of 6- to 15-story buildings suffered damage while a very small number of one- and two-story buildings were damaged. A 48-story building experienced only minor damage—a few broken windows. While many variables affect the amount of damage a building suffers as a result of an earthquake, the natural frequency of a building is a major contributing factor.

Concepts

- Natural frequency
- Resonance
- Seismic waves

Materials

Chenille wires, 12″, 3
Rigid foam base, 15 cm × 5 cm
Ruler
Scissors
Styrofoam® balls, 1½″ diameter, 3

Safety Precautions

While unlikely, vigorous shaking of the apparatus may cause the Styrofoam balls or the wires to shake loose. Wear safety glasses during this activity. Wash hands thoroughly with soap and water before leaving the laboratory. Please follow all laboratory safety guidelines.

Preparation

1. Obtain three chenille wires. Cut the wires to the following lengths: 25 cm, 20 cm, and 15 cm. *Caution:* The ends of the cut wires may be sharp.
2. Obtain three 1½″ diameter Styrofoam balls. Gripping one wire near the end, carefully push the end into a ball with a twisting motion. Push the wire so it is inserted more than half way through the ball, keeping the wire as centered in the ball as possible.
3. Repeat step 2 for the other two wires and balls.
4. Obtain a 15 cm × 5 cm rigid foam base. Insert the free end of the 25-cm chenille wire into the center of the base, being careful that the end of the wire does not poke through the bottom of the base.
5. Centering the wire width-wise, insert the 20-cm wire one cm from one end of the base.
6. Insert the 15-cm wire one cm from the opposite end of the base, in line with the other two wires (see Figure 1).

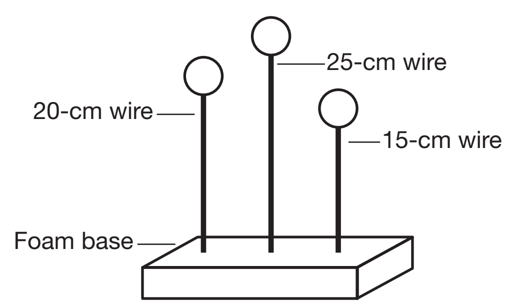


Figure 1.

Procedure

1. Place the foam base of the resonance apparatus on a flat surface.
2. Slowly slide the base forward and back as shown in Figure 2. Start with a low frequency and gradually increase the frequency until the tallest wire begins to resonate. Keep this frequency constant and observe the motion of the other two wires.
3. Gradually increase the frequency of the back-and-forth motion of the base until the 20-cm wire begins to resonate. Keep this frequency constant and observe the motion of the other two wires.
4. Once again, gradually increase the frequency of the back-and-forth motion of the base until the shortest wire begins to resonate. *Note:* This will be a very vigorous back-and-forth motion. Keep this frequency con-

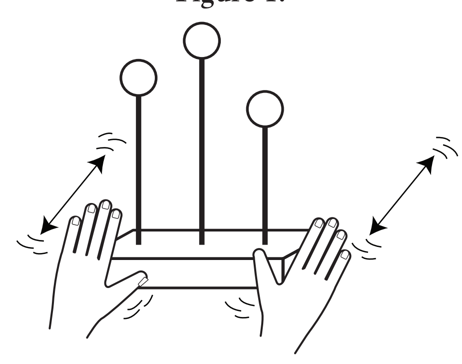


Figure 2.

stant and observe the motion of the other two wires.

5. Stop the motion of the base and instruct students to record all observations. Repeat steps 2 to 4 as needed to confirm observations.

NGSS Alignment

This laboratory activity relates to the following Next Generation Science Standards (2013):

Disciplinary Core Ideas: Middle School

MS-ESS2 Earth's Systems
- ESS2.A: Earth's Materials and Systems
- ESS2.B: Plate Tectonics and Large-Scale System Interactions

MS-PS4 Waves and Their Applications in Technologies for Information Transfer
- PS4.A: Wave Properties

Disciplinary Core Ideas: High School

HS-ESS2 Earth's Systems
- ESS2.A: Earth's Materials and Systems
- ESS2.B: Plate Tectonics and Large-Scale System Interactions

HS-PS4 Waves and Their Applications in Technologies for Information Transfer
- PS4.A: Wave Properties

Science and Engineering Practices

Developing and using models
Planning and carrying out investigations
Constructing explanations and designing solutions

Crosscutting Concepts

Patterns
Cause and Effect
Scale, proportion, and quantity
Systems and system models

Tips

- The foam base may be made from rigid foam insulation or florist foam. Use caution when using a sharp knife to cut the foam.
- If desired, stop all movement of the chenille wires before increasing the frequency.
- Flinn Scientific's *Exploring Earthquakes—Activity Stations Kit*, Catalog No. AP7406, is a great way for students to examine what causes earthquakes, why they are so unpredictable, and investigate factors that impact the effects of seismic activity.

Discussion

All objects including buildings have a *natural frequency* or set of natural frequencies at which they vibrate. The frequency of a vibration is the number of back and forth cycles *(oscillations)* that occur per second. The natural frequency of an object depends on its size and composition. Seismic waves traveling through the ground cause the ground to vibrate at its natural frequency. If the natural frequency of the ground matches the natural frequency of a structure built on that ground, then the motion of the building will be amplified, resulting in a vigorous oscillating movement. This higher amplitude oscillation is known as *resonance*. A common occurrence of resonance is a child being pushed on a swing. If the push is given in rhythm with the natural frequency of the swing, the child will swing higher and higher.

This demonstration illustrates how the length of a material affects its natural frequency. Three chenille wires of different lengths topped with identical Styrofoam balls are placed into a rigid foam base and moved back and forth, causing the wires to vibrate. When the back-and-forth motion of the base matches the natural frequency of one of the wires, that particular wire will vibrate vigorously, achieving resonance. By varying the frequency of the back-and-forth motion of the base, each wire will resonate at a different frequency.

Sample Data Table

Frequency	Observations
Low	*The longest wire resonated, moving back and forth vigorously. The medium-length wire only moved slightly and the shortest wire barely moved at all.*
Medium	*The medium-length wire resonated, moving back and forth vigorously. The longest wire and shortest wires vibrated slightly, but neither resonated.*
High	*The shortest wire moved back and forth very vigorously. The medium-length wire and the longest wires vibrated slightly.*

Sample Questions and Answers

1. Summarize the observed relationship between the resonance frequency and the length of the wire.

   The longer the wire the lower the frequency at which the wire resonates.

2. Based on your observations, do any of the wires share the same natural frequency? Give reasons for your answer.

   None of the wires shared the same natural frequency since none resonated at the same time.

3. Based on your observations, explain why a high percentage of 6- to 15-story buildings suffered considerable damage during the 1985 Mexico earthquake, while shorter and taller buildings did not.

   The middle-sized buildings must have had the same natural frequency as the ground shaking during the earthquake. This caused the6- to 15-story buildings to resonate. The shorter buildings would require a higher frequency and the tallest buildings would require a much lower frequency to resonate.

Reference

Geis, D.; Arnold, C. Mexico City as Seismic Laboratory. *Architecture*, July 1987, pp 75–77.

Materials for Earthquakes and Resonance are available from Flinn Scientific, Inc.

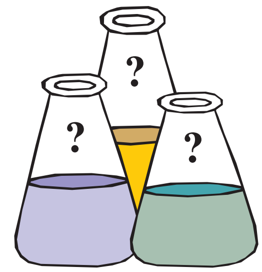
Catalog No.	Description
AP8862	Chenille Wires, Black, pkg/10
AP2280	Styrofoam Balls, 1½″, pkg/12

Consult your *Flinn Science Catalog Reference Manual* for current prices.

Mystery Solutions Match-up

Introduction

Challenge your students to solve the puzzle of the unknown solutions. How can they match three colorless mystery solutions with the same solutions their lab partners have? There is one catch—once a course of action has been determined, no visual comparisons allowed! A great lab for the first day of class, emphasizing good inquiry and communication skills with 100% participation guaranteed!



Concepts

- Observation
- Problem solving
- Scientific inquiry
- Scientific method

Materials (for each pair of students)

Unknown solutions in labeled pipets, 6 (see *Preparation* section)

Acetate sheets, 3 cm × 5 cm, 2

Notebook paper, 2 sheets

Paper towels

Pipet holder

Safety Precautions

Citric acid is a severe eye irritant. Wear chemical splash goggles, chemical-resistant gloves, and a chemical-resistant apron. Do not taste, touch, or smell any solutions or chemicals used in the lab. Remind students to wash their hands thoroughly with soap and water before leaving the laboratory. Please review current Safety Data Sheets for additional safety, handling, and disposal information.

Preparation

Part 1. Solution Preparation

Make a 2% solution of each of the following: aluminum potassium sulfate (alum), $AlK(SO_4)_2 \cdot 12H_2O$, citric acid, $C_6H_8O_7 \cdot H_2O$, and sodium bicarbonate (baking soda), $NaHCO_3$.

1. Weigh 2 g of one of the solids.
2. Add 50 mL of distilled or deionized (DI) water to a small beaker.
3. Add the solid to the beaker. Stir until dissolved.
4. Add an additional 50 mL of DI water to the beaker and stir. Label.
5. Repeat steps 1–4 with each of the remaining solids in separate beakers.

Part 2. Preparation of Pipets

1. Use a permanent marker to label a set of six thin-stem disposable pipets, each with a different letter or number such as A, B, C, and 1, 2, 3. Mark enough sets for each pair of students.
2. Cut off all but 1 cm of the stem from each pipet.
3. Draw a half-bulb of the 2% alum solution in pipets marked as A and pipets marked as 2.
4. Draw a half-bulb of the 2% baking soda solution in pipets marked as B and pipets marked as 3.
5. Draw a half-bulb of the 2% citric acid solution in pipets marked as C and pipets marked as 1.
6. Place a set of six (A, B, C, 1, 2, 3) filled pipets in a pipet holder (empty cassette tape case, see Figure 1).

Part 3. Preparing the Acetate "Spot Plates"

1. Cut an overhead transparency acetate sheet into 3 cm × 5 cm pieces.
2. Using a permanent marker, place a dark dot in opposite corners of each small acetate sheet. *Note:* The dark dots make it easier to find the acetate sheets should they fall onto the floor as well as help the instructor confirm the sheets were

returned to the pipet holders at the end of the lab.

3. Slide two acetate spot plates into each of the pipet holders, behind the pipets (see Figure 1).
4. Close the boxes and rubber band them.

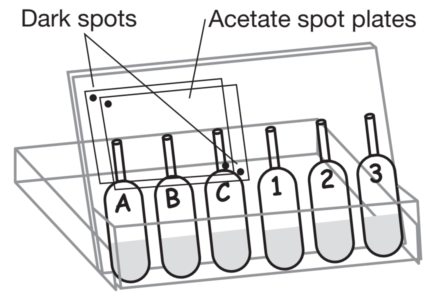


Figure 1.

Procedure

1. With students working in pairs, assign each pair a group number (1 through 15).
2. Hand out the prepared pipet holders, one setup to each pair of students. Tell students to look at the boxes but do not open them up yet.
3. Explain the objective of the lab is to determine which solutions in the numbered pipets match the corresponding solutions in the lettered pipets. One partner may only use the numbered pipets and the other partner only the lettered pipets.
4. Allow students a few minutes to brainstorm different ways to solve the problem, writing down their ideas.
5. As a class, have the students discuss the ideas they came up with; invariably a student will offer the approach of mixing the solutions together to see what happens. Discuss the merits of this approach, and instruct them all to give it a try. Show them how to use the cut-off pipets to squeeze out drops and mix them on the acetate sheet, and how to avoid contamination—never placing the tip of a pipet into a drop of a different solution. Stirring the drops together will not be necessary—the reactions will take place immediately and the results are obvious.
6. Explain to the students there is one final restriction—they are not to visually compare their results. Their only means of communicating their findings is verbally, by describing their results orally and in writing.
7. Have each pair of students place a visual barrier, such as a notebook or folder, between their work spaces and then let them open the pipet holders and begin.
8. In the end, discuss the method and reasoning process as an entire class.

Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures, and review all federal, state and local regulations that may apply, before proceeding. Solutions on the acetate sheets may be wiped up with a paper towel and thrown away in the regular trash. All leftover solutions may be rinsed down the drain with plenty of excess water according to Flinn Suggested Disposal Method #26b.

NGSS Alignment

This laboratory activity relates to the following Next Generation Science Standards (2013):

Disciplinary Core Ideas: Middle School
- MS-PS1 Matter and Its Interactions
  - PS1.A: Structure and Properties of Matter
  - PS1.B: Chemical Reactions

Disciplinary Core Ideas: High School
- HS-PS1 Matter and Its Interactions
  - PS1.A: Structure and Properties of Matter
  - PS1.B: Chemical Reactions

Science and Engineering Practices
- Planning and Carrying Out Investigations
- Analyzing and Interpreting Data
- Constructing explanations and designing solutions
- Obtaining, Evaluating, and Communicating Information

Crosscutting Concepts
- Cause and effect
- Structure and function

Tips

- Students may want to taste, smell or feel the solutions for identification. Remind students that such practice is not allowed in the laboratory.
- Extra-large bulb pipets (available from Flinn Scientific, Catalog No. AP1445) are great for holding thin-stem pipets in place in the cassette boxes. Cut and discard the stems from the extra-large bulbs and then cut the bulbs in half. Place six of the half-bulb “cups” in the cassette box. Insert one filled pipet into each cup.

- To avoid students copying from other groups, number or letter each pair of boxed pipets differently—4, 5, 6 and D, E, F, etc.
- The purpose of the "no visual comparison" restriction is to prevent one partner from monopolizing the lab. For a greater challenge, add a "no talking allowed" restriction. Students must then describe their results and reasoning in writing and pass their papers back and forth.
- Vinegar may be used in place of the citric acid solutions. However, students may be able to identify the solution by its smell. Ascorbic acid (vitamin C) may also be used. Vitamin C tablets have additional binders that may cloud the solution.
- A video of this lab activity, Mystery Solutions Lab, presented by Bob Becker, is available for viewing as part of the Flinn Scientific Best Practices for Teaching Chemistry Videos. Please visit the Flinn Web site at http://www.flinnsci.com for viewing information. The activity is found with the *Scientific Method* videos.

Discussion

The *scientific method* is a way of solving problems using a systematic approach. An organized strategy such as the scientific method is an effective way of approaching a problem. A wide variety of strategies may be implemented and the following is a list of steps that scientists may use to solve a problem.

Typical steps in the scientific method

1. Define a *problem* or ask a question — A clear statement of the problem or question is a crucial step in beginning an investigation.
2. Make *observations* about the problem — All possible information pertaining to the problem will be helpful in writing a plausible explanation and in designing a good experiment.
3. Develop a *hypothesis* — This is a possible answer or tentative explanation to the problem or question. It should be based on the facts and observations and should be capable of being tested.
4. Design and carry out an *experiment* — Experimental testing will provide evidence that either supports or contradicts the hypothesis. Several factors must be determined before conducting an experiment.

   Variables: The factors that influence the outcome of an experiment.

   Constants: All other factors, except the one whose effect is being studied, should remain the same throughout an experiment.

   Independent Variable: The variable that is intentionally changed or manipulated by the experimenter.

   Dependent Variable: The variable being measured or watched, also called the *outcome* or the *responding variable*.
5. Record and analyze *data* — Data, such as observations and measurements, are recorded and then analyzed. If the data support the hypothesis, then the conclusion would state that the hypothesis is correct. If the data contradict the hypothesis, then a new hypothesis must be developed and tested.
6. Draw a *conclusion* — Scientists base their conclusions on observations made during experimentation.

Keep in mind, however, that although the above list of steps may be a "typical" approach, the strategy and the order of steps may vary greatly from problem to problem.

Guided-inquiry activities simulate the scientific method—students look at data, search for patterns or relationships, and try to identify guiding principles that will explain the data. Guided-inquiry activities are most successful if students understand that the activity replaces the lecture. Students are more likely to take responsibility for learning when they are actively engaged in the process of "constructing knowledge."

Even though understanding the chemistry involved is not the focus of this activity, students may be curious as to what took place. The reaction of citric acid and sodium bicarbonate produces sodium citrate and carbonic acid (Equation 1).

$$C_6H_8O_7(aq) + 3NaHCO_3(aq) \rightarrow Na_3C_6H_5O_7(aq) + 3H_2CO_3(aq) \qquad \textit{Equation 1}$$

The carbonic acid then decomposes into water and carbon dioxide (Equation 2). The carbon dioxide forms the bubbles that students observe.

$$H_2CO_3(aq) \rightarrow H_2O(l) + CO_2(g) \qquad \textit{Equation 2}$$

Sodium bicarbonate is the salt of the weak acid, carbonic acid, H_2CO_3. When dissolved in water, sodium bicarbonate, $NaHCO_3$, forms a slightly basic solution (Equation 3).

$$HCO_3^-(aq) + H_2O(l) \rightleftarrows H_2CO_3(aq) + OH^-(aq) \qquad \textit{Equation 3}$$

Alum, $AlK(SO_4)_2$, when dissolved in water, forms the cations $Al^{3+}(aq)$ and $K^+(aq)$ in solution, along with the sulfate anion, $SO_4^{2-}(aq)$. When the alum and baking soda solutions are combined, a white precipitate of aluminum hydroxide is formed (Equation 4).

$$Al^{3+}(aq) + 3OH^-(aq) \rightarrow Al(OH)_3(s) \qquad \textit{Equation 4}$$

None of the products of the citric acid and alum reaction are insoluble in water; therefore no change is observed.

Sample Test Method and Observations

Mixtures of solutions were systematically tested pairwise within each set of three solutions. Results of each mixture were recorded and compared.

A + B = cloudy white	*1 + 2 = no visible reaction*
A + C = no visible reaction	*1 + 3 = bubbles*
B + C = bubbles	*2 + 3 = cloudy white*

A = 2
B = 3
C = 1

Solution B was the only solution involved in both the cloudy white and the bubbling reactions. Likewise for solution 3, therefore solution B must be the same as solution 3. C was the other solution involved in making bubbles, as was solution 1. Therefore solution C must be the same as solution 1. By process of elimination, solution A must be the same as solution 2 (both solutions A and 2 were involved in the cloudy white precipitate reaction and the combination that produced no reaction).

Acknowledgment

Special thanks to Bob Becker, Kirkwood High School, Kirkwood, MO, for providing the idea and the instructions for this activity to Flinn Scientific.

Materials for *Mystery Solutions Match-up* are available from Flinn Scientific, Inc.

Catalog No.	Description
AP7323	Match the Mystery Solutions—Guided-Inquiry Laboratory Kit
A0265	Aluminum Potassium Sulfate, 100 g
C0231	Citric Acid, Monohydrate, 100 g
S0043	Sodium Bicarbonate, 500 g
AP1519	Pipet Holder Cassette Case
AP1444	Pipet, Beral-type, Thin-Stem, Pkg/500
AP8464	Acetate Sheets, Pkg/100

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.

Mystery Light Block

Scientific Method Demonstration

FLINN SCIENTIFIC CHEM FAX!

Introduction

A rectangular block of paraffin is exposed to a source of light, creating a discrepant event. Students make observations, ask questions, make predictions, propose experiments, and develop a hypothesis about the paraffin block.

Concepts

- Scientific method
- Making observations
- Discrepant events

Materials (for each demonstration)

Aluminum foil, 4½″ × 2¼″	Hot plate
Paraffin blocks, 4 oz, 2	Pan, non-stick
Flashlight	Scissors

Safety Precautions

Exercise caution when using a hot plate and melted wax. Do not heat the pan at a high setting. Remove the pan from the hot plate immediately after use. Wear chemical splash goggles and heat-resistant gloves whenever working with heat in the laboratory. Wash hands thoroughly with soap and water before leaving the laboratory. Follow all laboratory safety guidelines. Please review current Safety Data Sheets for additional safety, handling, and disposal information.

Preparation

1. Cut a piece of aluminum foil slightly smaller than the paraffin block. An easy method is to firmly press one paraffin block flat onto the aluminum foil to leave an impression. Cut the foil just inside the borders of the wax impression.
2. Place the aluminum foil on top of one paraffin block.
3. Place a second block on top of the foil, making sure the foil is not visible between the two paraffin blocks (see Figure 1). Trim the piece of foil if necessary. This is the "Mystery Light Block."

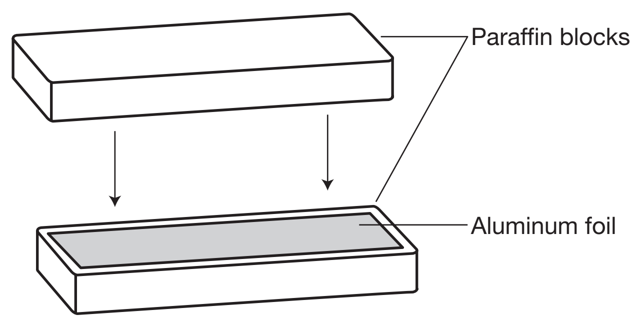


Figure 1.

4. Place the pan on a hot plate and turn the hot plate on low heat.
5. Wearing heat-resistant gloves, hold the two paraffin blocks together with all sides aligned.
6. Place the Mystery Light Block on one edge (seam side down) on the bottom of the pan until the paraffin just starts to melt. Lightly press the block down and move it back and forth to ensure uniform melting.
7. Lift the Mystery Light Block away from the heat and rotate the block one quarter turn to heat seal another edge. Repeat step 6.
8. Continue to repeat steps 6 and 7 until all four edges are sealed and smooth.
9. Turn off the hot plate and remove the pan and the Mystery Light Block from the heat. Allow to cool.

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Procedure

1. Without introduction and with the classroom lights on, hold the Mystery Light Block horizontally so the two layers are visible to the students. Do not identify the composition of the block.
2. With the classroom lights on, the top layer should look white and the bottom layer gray (see Figure 2).
3. Ask students to make observations. Help them differentiate between valid observations and assumptions. For example, "It's made of wax," is an assumption, but "It looks waxy," is a valid observation.

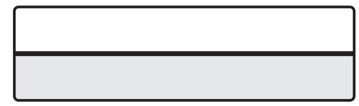

Figure 2.

4. Once students have completed their observations, ask them to predict what would happen if you flipped the block over so the top layer is now on the bottom and vice versa.
5. Flip the block over. Students may be surprised to see that the white layer is still the top layer. Ask students to suggest experiments that could be conducted to investigate the appearance of the block and explain the apparent discrepancy. Emphasize that nothing may be done that would damage or destroy the block.
6. If students do not suggest using a light source, show them a flashlight and ask what tests could be done using the flashlight.
7. Follow students' suggestions using the flashlight and paraffin block. Make sure students are specific about the tests they would like to try—where and how to shine the light and how to hold the block. With each new display, have students describe the results.
8. Following the experimentation, ask students to make a hypothesis about the composition of the block. If they hesitate, help them understand that a hypothesis simply needs to be a reasonable explanation for their observations. The hypothesis may or may not be correct.
9. Conclude by explaining to the students that they have just used the scientific method. They made observations, suggested experiments, made more observations, and developed a hypothesis.
10. If desired, the next day show the students how the block was made using the remaining two paraffin blocks and another piece of aluminum foil. Do not heat seal the paraffin blocks, however.

Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures, and review all federal, state and local regulations that may apply, before proceeding. The materials used in this activity may be stored for future use or thrown away in the regular trash.

NGSS Alignment

This laboratory activity relates to the following Next Generation Science Standards (2013):

Disciplinary Core Ideas: Middle School

- MS-PS1 Matter and Its Interactions
  - PS1.A: Structure and Properties of Matter
- MS-PS4 Waves and Their Applications in Technologies for Information Transfer
  - PS4.B: Electromagnetic Radiation

Disciplinary Core Ideas: High School

- HS-PS1 Matter and Its Interactions
  - PS1.A: Structure and Properties of Matter
- HS-PS4 Waves and Their Applications in Technologies for Information Transfer
  - PS4.B: Electromagnetic Radiation

Science and Engineering Practices

- Asking questions and defining problems
- Developing and using models
- Constructing explanations and designing solutions
- Engaging in argument from evidence

Crosscutting Concepts

- Patterns
- Cause and effect
- Energy and matter

Tips

- This is a good activity for early in the school year to model the scientific method—including understanding the difference between careful observations and assumptions, experimentation and data collecting, and the importance of making a reasonable hypothesis based on observations. The demonstration may also be used as an introduction to reflection of light.
- This activity may also be done as a student inquiry lab. To supply eight student groups each with a Mystery Light Block, make "miniature" blocks by scoring across the center of each rectangular paraffin block with a sharp knife. Use a table edge to break the block in half, making two 2¼″-square blocks. Score and break these blocks again to make four 2¼″ × 1⅛″ rectangles from each original paraffin block. Follow the *Preparation* procedure to complete the Mystery Light Blocks. Students make observations and collect data in teams. Emphasize that they may not damage the Mystery Light Blocks in any way; otherwise, they may try to scratch the blocks or break them apart.
- A video of this demonstration, *Paraffin Paradox*, presented by Steve Long, is available for viewing as part of the Flinn Scientific "Best Practices for Teaching Chemistry" Videos. Please visit the Flinn Website at http://www.flinnsci.com for viewing information. The activity is found with the *Scientific Method* videos.

Discussion

Discrepant event demonstrations engage students' natural curiosity using the element of surprise. As students observe, predict, propose experiments, and make hypotheses, real learning takes place. The scientific method is sometimes presented to students as a rigid sequence of events. The scientific method, however, is not rigid, it is a process—a process of discovery! Discovery begins when observations are made and then students try to understand what they have observed by asking key questions and proposing possible answers. The process of discovery continues as experiments are designed and conducted to test whether proposed answers to these questions are valid.

When the Mystery Light Block is flipped over, students observe that the difference in "color" of the two layers is not due to a physical difference of the layers. When light enters one layer of the block, the sheet of aluminum foil reflects the light back into that layer, scattering the light and sending more light out the sides of the block. At the same time the foil barrier prevents much of the light from entering the bottom layer. Thus one layer appears white and the other gray.

Sample Questions and Answers *(Student answers will vary.)*

1. Predict what will happen if the block is flipped over 180 degrees.

   The white layer will be on the bottom and the gray layer will be on top.

2. Record any additional observations of the block after it was flipped over.

   The top layer is still white and the bottom gray.

3. Suggest an experiment that could be done to explain your observations, without damaging the block in any way.

   Some possible suggestions are shake the block; vary the orientation of the block; shine a light at different angles onto the block; place the block in water, etc.

4. Record any new observations as experiments are conducted.

   When a light shines on one broad side of the block, that side appears white and the opposite side appears dark, no matter how the block is oriented. When a light shines on an edge, directly at the interface between the two layers, the color (brightness) of each layer is (nearly) the same. Note to teacher: In the first scenario described above, the contrast in brightness is more dramatic if the classroom lights are turned off. In the second scenario, the brightness of the two layers will be more uniform if light other than the flashlight is eliminated.

5. Write a hypothesis to explain your observations of the block.

   Accept all reasonable explanations.

Materials for *Mystery Light Block—Scientific Method Demonstration* are available from Flinn Scientific, Inc.

Catalog No.	Description
AP7341	Mystery Light Block —Scientific Method Demo Kit
AP6767	Student Flashlight
AP7234	Hot Plate, Flinn, 7″ × 7″

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.