ACTIVITY 8-1
A PRESUMPTIVE TEST FOR BLOOD

Objective:
By the end of this activity, you will be able to:
Use the Kastle-Meyer Presumptive Blood Test to determine if a given stain contains blood.

Scenario:
At dusk, a young man was seen riding his bicycle along the narrow, winding road that encircled a lake. On that same quiet road, an animated young couple was seen speeding around the many turns in the road. They were in a hurry to arrive at a friend’s party at the lake. In his haste, the driver of the car lost control of the car while trying to swerve to avoid the young man on the bike. Unfortunately, the biker was hit from behind, causing him to be knocked off his bike and to fall down the hill toward the lake. The young driver of the car panicked and, without looking back, fled the scene of the crime. Although somewhat injured, the biker was able to provide a description of the car to the police.

Later that evening, the police arrived at the party on the lake to question the owner of the car. Although there was no visible blood on the car, the police did find a red stain on the car’s bumper. At first the young driver said it was red paint or perhaps the blood from a squirrel he had struck the day before. Is the stain blood or paint? If it is blood, is it possible to distinguish human blood from animal blood? In this activity you will perform tests that confirm the presence of blood.

Time Required to Complete Activity: 45 minutes

Materials:
Activity Sheets for Activity 8-1
ketchup (1 oz or 10 ml)
blood from animal source (1 oz or 10 ml)
cloth or shirt with dime-sized blood stain
cloth or shirt with dime-sized ketchup stain
20 mL 3% hydrogen peroxide solution in dropper bottle
20 mL 95% ethyl alcohol in dropper bottle
20 mL distilled water in dropper bottle
20 mL 2% phenolphthalein solution in dropper bottle
biohazard container
latex or nitrile gloves

Safety Precautions:
Wear protective gloves.
Dispose of all samples in a biohazard container provided.
Assume that all red solutions are blood and handle according to safety regulations.
All procedures should be done while wearing protective gloves. Do not contaminate any of the reagents. Be sure to drop the solutions onto the cotton swab without touching the cotton swab. Return the caps of all reagent bottles to the correct reagent bottle. Do not switch the caps from one bottle to the other.

**Background:**
Dried drops of red fluid found on a murder weapon, clothing, or automobile are noted, photographed, and analyzed. Did blood cause the red stain? If the red stain is not blood, then valuable time and money can be saved by not sending the red stain in to the laboratory for further testing. If it is determined that the red stain is blood, then further testing needs to be ordered to identify the source of the blood as human or animal.

A sample of the stain is tested using a presumptive chemical reagent. The Kastle-Meyer test is a catalytic color test that will produce a color change in the presence of blood. When phenolphthalein and hydrogen peroxide react with heme (iron) molecules in hemoglobin, the presence of blood is indicated by a pink color. A negative Kastle-Meyer test indicates the absence of blood. Because animal blood also contains heme molecules, it will also give a positive result. If animal blood is present and pertinent to the case, then additional tests can be performed to determine what type of animal blood is present.

**Procedure:**
1. Obtain a section of cloth that contains a known bloodstain (positive control). Before testing any unknown stains, it is important to check all reagents on a known sample of blood. If you do not get the expected results on blood, then you know that your reagents were malfunctioning and you need to replace them.
2. Wet a cotton swab with four drops of distilled water and gently rub the wet swab on the known bloodstain.
3. Drop two drops of ethyl alcohol onto the swab (don’t allow the dropper to touch the swab).
4. Drop two drops of the phenolphthalein solution onto the swab (don’t allow the dropper to touch the swab).
5. Drop two drops of the hydrogen peroxide onto the swab (don’t allow the dropper to touch the swab).
6. A positive pink color will appear within seconds if blood is present. Record your results in Data Table 1. (This is your positive control demonstrating what happens when blood is present.)
7. Using a permanent marker, record your initials next to the stain that was just tested.
8. Dispose of all used cotton swabs and bloodstain samples into the Biohazard Waste container.
9. Using clean cotton swabs, repeat steps 1 to 8 using the shirt containing the ketchup stain. (This is your negative control since ketchup is not blood.)
10. Record the appearance of the ketchup test in Data Table 1.
11. With fresh cotton swabs, repeat steps 1 to 8 on the section of the shirt containing the unknown stain 1.
12. Using fresh cotton swabs, repeat steps 1 to 8 on the section of the shirt containing the unknown stain 2.

Data Table 1: Table of Test Results

<table>
<thead>
<tr>
<th>Stains</th>
<th>Color Pink or not pink?</th>
<th>Describe Your Observations Is it blood or not blood?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blood stain (positive control)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ketchup (negative control)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown 2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Questions:
1. Complete the following Data Table indicating the role or function of each of the chemical reagents used in this experiment.

Data Table 2: The Role of Chemical Reagents in Blood Sample Analysis

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Distilled water</td>
<td></td>
</tr>
<tr>
<td>2. Ethyl alcohol</td>
<td></td>
</tr>
<tr>
<td>3. Phenolphthalein</td>
<td></td>
</tr>
<tr>
<td>4. Hydrogen peroxide</td>
<td></td>
</tr>
</tbody>
</table>

2. Explain why you need to use both a positive and negative control before testing the unknown stains:
   a. Positive control
   b. Negative control
3. Should the pink color first be evident:
   a. when applying the phenolphthalein to the cotton swab?
   b. when applying the hydrogen peroxide to the cotton swab?
Explain your answers.
4. If animal blood is different from human blood, how is it possible to get a positive reaction with the Kastle-Meyer test using dog blood?
5. List two types of substances that might produce a false-positive test when performing the Kastle-Meyer test for the presence of blood.
   a. Substance 1 _________
   b. Substance 2 _________
6. Why is it important to use a cotton swab when doing this test?
7. Why aren’t the reagents applied directly to the original bloodstain?
8. Suppose that a red stain was found in a bathtub along with some bathwater. Would it be possible to detect the blood since it might have been diluted? Explain your answer.

Further Research:
1. Research the history of using this method as a presumptive blood test. Investigate the role of each of these scientists:
   a. Louis-Jacques Thenard
   b. Christian Freidrich Schonbein
   c. Dr. Kastle
   d. Dr. Meyer
2. Research how to distinguish dog blood from human blood.
3. Investigate the presumptive test for the presence of semen. Describe how this test is performed.
4. If a man has had a vasectomy, how will this affect the results of tests to detect semen? Explain.
5. Research each of the following cases. Explain the role of blood analysis in helping to solve the crime.
   b. O.J. Simpson case (1994)
ACTIVITY 8-2
BLOOD TYPING

Objectives:
By the end of this activity, you will be able to:
1. Perform a simulated blood test.
2. Describe the procedure for testing blood.
3. Analyze different blood tests to determine the blood type of a suspect.
4. Describe how blood test results are used to determine if an individual is linked to crime-scene blood evidence.
5. Describe agglutination of red blood cells.
6. Describe the protein–antibody reaction that occurs when typing blood.
7. Describe the role of blood typing in forensics.

Time Required to Complete Activity: 45 minutes

Materials:
(per group of three students)
Activity Sheets for Activity 8-2
Ward’s Natural Science Kit 360021 or similar artificial blood-typing kit that includes:
- simulated human blood types
- antibodies for testing type A, B and Rh blood
- plastic blood testing slides each containing three wells
- plastic or paper cup labeled “Biological Waste”
- 10% bleach solution in spray bottle
- paper towels
- latex or nitrile gloves
- marking pen
- red pencil or marker
- toothpicks

Safety Precautions:
Handle artificial blood as if it were actual human blood to practice lab safety techniques. Any blood spills must be cleaned using a 10-percent bleach solution. Dispose of all waste in a container labeled “Biological Waste.” Wear disposable gloves. If a student is allergic to latex, substitute a different type of glove, such as nitrile. Students should be careful to avoid spilling any bleach on themselves or on their clothing. Bleach can cause skin and eye irritation and can remove color from fabric immediately.

Background:
Blood typing is a common tool used to solve crimes. It may allow the examiner to match or exclude a suspect from a crime scene. To detect the presence of blood proteins, you will add specific antibodies to individual drops of blood and determine whether clumping (agglutination) occurs.
Procedure:

1. Obtain six clean plastic three-well slides.
2. Place the slides on a clean, white sheet of paper.
3. Write the name of the blood donor in the top left-hand corner of the plastic slide. On the clean white paper, write the name of the blood donor above the slide.
4. Put on your gloves for the rest of the procedure.
5. Add two drops of blood to each of the three wells of the slide labeled Suspect 1.
6. Repeat the process for each of the Suspects 2, 3, 4, Crime Scene, and the Victim slide.
7. Add two drops of Anti-A serum (blue bottle) to each of the six wells labeled A.
8. Add two drops of Anti-B serum (yellow bottle) to each of the six wells labeled B.
9. Add two drops of Anti-Rh serum to each of the six wells labeled Rh.
10. Gently rock each slide back and forth and up and down. (Do not let the blood from one well contaminate the blood from another well!) You can also use a toothpick to help mix the contents. A new toothpick must be used in each of the wells. You will need 18 toothpicks. Stir gently to avoid scratching the plastic wells.
11. Wait five minutes to allow reactions to occur.
12. Observe the blood samples. When using this artificial blood:
   a. A cloudy, opaque, or gooey mixture is a positive reaction indicating the presence of a blood-type protein.
   b. A clear mixture is a negative reaction indicating the absence of a blood-type protein.

Note: Placing each slide on an overhead projector may help in examining the reactions.
13. Record your data on Figure 1. Include the suspect’s name and blood type.

14. For a positive reaction (indicating the presence of the blood-type protein), shade in the circle using a red-colored pencil or marker. If the blood test is negative, indicating the absence of blood-type protein, leave the circle empty.

15. Dispose of all typing materials in the “Biological Waste” container provided by your instructor.

**Blood Results:**
1. To indicate a positive reaction (protein present), use a red pencil or marker to shade in the well.
2. To indicate a negative reaction (no protein), leave the well blank.
3. Label each reaction slide with the blood type.
Questions:

1. Why is simulated (man-made) blood instead of real human blood used in this activity?
2. Explain why it is necessary to type the victim’s blood when trying to determine if any of the blood found at the crime scene belongs to a particular suspect.
3. In this lab activity, how many different blood-type proteins were examined?
4. List all of the blood-type proteins examined in this activity.
5. Is it possible to exclude any of the suspects based on blood types? Explain your answer.
6. Based on your results, does the crime-scene blood match the blood type of any of the four suspects? Explain your answer.
7. If blood from one of the suspects matches the crime-scene blood, does that prove that the suspect is guilty? Explain your answer.
8. Poor laboratory techniques may lead to erroneous results that could impact the outcome of a trial. Describe some examples of poor laboratory techniques involved in a blood-typing analysis that might produce erroneous results.
9. Explain why identifying the blood type found in both the suspect and at a crime scene as AB− provides a higher degree of probability of a match than if the blood type found in the suspect and at the crime scene is O+.
10. Explain why white blood cells are not used in blood typing.
Further Research:

1. Research cases of innocent people who were convicted as a result of laboratory errors. (Refer to The Innocence Project, www.innocenceproject.org)
2. Research what other blood-type proteins are used in blood typing in addition to the A, B, and Rh proteins.
3. Research information on protein and antibodies. Explain why the red blood cells clump, or agglutinate, when mixed with certain antibodies.
4. Investigate the predominant blood type found in each ethnic group:
   a. European
   b. Asian
   c. African

Math Connection:

1. Explain how the laws of probability are used in determining the probability that a particular person’s blood will match the blood found at a crime scene.
2. If blood is found at a crime scene, describe what testing is done to determine if the blood is human blood or not human blood.
3. Research how it is possible to determine blood types from other body cells such as cheek cells or skin cells. (Hint: research secretors and non-secretors)
4. Paternity cases: If a man is the biological father of a child, he has a moral and a legal obligation to provide child support for at least the first 18 years of the child’s life. Explain how blood typing can exonerate a man from paternity, but explain why it alone cannot determine paternity.
5. Investigate the role Rhesus monkeys played in the research involving the Rh protein.
ACTIVITY 8-3
BLOOD-SPATTER ANALYSIS: EFFECT OF HEIGHT ON BLOOD DROPS

Scenario:
The police examined the blood spatter at a crime scene. From the size of the droplets, it appeared that the blood had passively dripped as the injured person walked across the floor. The person may have experienced a second injury, because two different patterns of blood spatter appeared halfway across the room. The second injury seemed to be from a source higher up on the person’s body.

By examining the size and shape of blood spatter, forensic scientists are able to reconstruct a crime. A partial story of the crime emerges as the blood-spatter analysis starts to “tell the story.”

In this activity, you will experiment with dropping artificial blood from different heights, and you will make observations about the effect of height on blood spatter.

Objectives:
By the end of this activity, you will be able to:
1. Prepare reference cards of blood spatter produced from varying heights.
2. Compare and contrast the blood spatter produced from different heights.
3. Distinguish between the blood spatter formed at the point of contact with satellite blood droplets.
4. Distinguish between satellite droplets and spike-like formations of blood droplets.
5. Form a hypothesis about the effect of height on the size and shape of blood-spatter droplets.

Time Required to Complete Activity:
Two 45-minute class periods (one period to do the blood drop, the second period to measure the blood drops)

Materials:
(per group of four students)
2 dropper bottles of simulated blood
12 five-by-eight-inch index cards
4 meter sticks
4 six-inch rulers showing cm or four calipers
newspapers

Safety Precautions:
Cover the floor in the work area with newspaper. Simulated blood may stain clothing.
Background:
A blood-spatter pattern is created when a wound is inflicted and blood leaves the body. This pattern can help reconstruct the series of crime-scene events surrounding a shooting, stabbing, or beating. Recall that blood forms droplets as it falls from a wound. A drop of blood that falls on a flat surface will not totally flatten out—the blood drop will have a curved surface. The reason for this shape is the cohesive nature of blood. Blood tends to pull together because of cohesion and resist flattening out on a surface. The result is that the surface of the blood is elastic, giving the top of the blood spatter a spherical appearance.

If any of the blood does overcome cohesion and separates from the main droplet of blood, it will form small secondary droplets known as satellites.

If blood is dropped onto a smooth surface, such as glass or marble, the edge of the drop of blood appears smooth and circular. However, if the blood lands on a porous surface, such as wood or ceiling tile, then the edge of the drop of blood may form small spikes or extensions. Notice that spikes are still connected to the main droplet of blood, whereas satellites are totally separated.

As you compare the blood dropped from various heights, note which height causes blood to form more satellites.

Procedure:
Part A: Preparation of blood-spatter reference cards for blood dropped from different heights
1. Spread newspaper on the floor of the work area.
2. You will prepare two 5 × 8 cards for each height used in the blood drop.
3. Label the top-right corner of each card with the height of the blood drop and your initials.
4. Place 12 labeled 5 × 8 index cards on the newspaper.
5. Use a meter stick to help you measure the distance above the card.
6. With the help of your partners holding a meter stick vertically for measurement, squeeze out one drop of simulated blood from a height of 25 cm onto one of the index cards. Hold your hand steady and slowly release the one drop of blood. Aim toward the top of the card.
7. Repeat this process preparing a second card held at 25 cm.
8. Repeat this process for dropping blood for heights of 50,
100, 150, 200, and 250 cm. Remember to prepare two cards for each height.

9. Allow index cards to dry. Do not move the cards until they are dry (at least 20 minutes). When you do move the cards, do not turn them on their sides, because the blood will be affected by gravity.

10. Measure the diameter of each of the spatter patterns and record the data in Table 1. Take your measurements at the widest part of the main drop. Do not include the satellites or spikes within your measurement.

11. Determine the average diameter for the blood spatter for each height, and record it in the Data Table.

12. Prepare a bar graph or histogram comparing the effect of height on the average diameter of the blood drop. Your graph should contain title, labeled x-axis and y-axis and an appropriate scale.

Data Table: Effect of Height on Diameter of Blood Drop

<table>
<thead>
<tr>
<th>Height of drop (cm)</th>
<th>Diameter of drop (cm)</th>
<th>Diameter of drop (cm)</th>
<th>Average diameter (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>150</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>200</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>250</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Questions:
1. Is there a relationship between the height from which the blood is dropped and the size of the blood-spatter droplets? Support your answer with data.
2. True or False: As the height from which the blood is dropped increases, the size of the blood spatter continues to increase. Support your answer with data.
3. Blood is dropped from heights of 25 cm and 250 cm. Compare and contrast the outer edges of blood droplets produced from these two heights.
4. Examine the blood spatter produced by dropping blood from the six different heights. Is there a relationship between the height from which the blood is dropped and the number of satellites produced? Support your answer with data.
5. Compare your results with your classmates.
   a. Were your results similar to those of your classmates? If not, how did they differ?
   b. If someone accidentally dropped two or more drops of blood in the same location, what effect would it have on the blood-spatter pattern?

Further Study:
A drop of blood will continue to pick up speed until it reaches its terminal velocity.
1. What is terminal velocity?
2. What factors affect the terminal velocity of a substance?
3. What is the terminal velocity of blood?
4. How far does blood need to fall until it reaches its terminal velocity?

You may also research blood-spatter patterns at these Web sites:
www.bloodspatter.com/bloodspatter.pdf
ACTIVITY 8-4
BLOOD-SPATTER IMPACT ANGLE

Scenario:
Two police officers walk into a neighborhood convenience store. They soon realize that no one is inside the store. They discover a series of blood-spatter patterns on the walls and ceiling. “What happened here?” says one officer as she walks around the store. The officers call in the situation, and a forensics team is dispatched to the scene. Forensic scientists will investigate the crime scene and seek answers for the questions listed below:

- Whose blood is this?
- Does it belong to just one or several people?
- How many people were injured?
- If more than one person was injured, is it possible to tell who was injured first?
- What type of injury caused the blood loss?
- What type of weapon caused the injury?
- If the weapon was a gun, from which direction was the bullet fired? Did the shooter point the gun upward, downward, or straight ahead?
- In what direction(s) did the injured person move?

Objectives:
By the end of this activity, you will be able to:
1. Create blood-spatter patterns from different angles of impact.
2. Examine the relationship between angle of impact and blood-spatter patterns.
3. Calculate the angle of impact from blood-spatter patterns.

Time Required to Complete Activity:
Two 45-minute class periods
First period: create blood-spatter patterns from different angles
Second period: measure blood spatter and calculate angle of impact

Materials:
(per group of four students)
Activity Sheets for Activity 8-4
1 dropper bottle of simulated blood
4 five-by-eight-inch index cards
2 meter sticks
newspapers
2 clipboards
1 protractor
1 roll masking or drafting tape

Safety Precautions:
Cover the floor in the work area with newspaper. Simulated blood may stain clothing and furniture, so care should be taken to avoid spilling blood.
**Background:**

Blood-spatter analysis is a powerful forensic tool. Spatter patterns allow investigators to reconstruct what happened at a crime scene. The blood-spatter patterns “tell a story” of the crime and help the investigators determine if eyewitness accounts are consistent with the evidence. To study impact angle, you will need to use trigonometry math skills.

Use trigonometric functions to determine the impact angle for any given blood droplet.

By accurately measuring the length and width of a bloodstain, you can calculate the impact angle using the following sine formula:

\[
\sin \theta = \frac{\text{opposite}}{\text{hypotenuse}}
\]

To determine the angle of impact, take the inverse \( \sin \) of 0.5, which is 30 degrees.

**Procedure:**

**Part B: Creating blood spatter from different angles of impact**

In this activity, you will drop blood onto 5 × 8 index cards set at various angles. You will drop the blood from 30 cm from the point of impact on the 5 × 8 card. You will observe how the angle of impact affects the size and shape of the blood spatter.

You will drop simulated blood onto 5 × 8 cards that are set to represent impact angles of:

- 10 degrees
- 20 degrees
- 30 degrees
- 40 degrees
- 50 degrees
- 60 degrees
- 70 degrees
- 80 degrees

You will be working in groups. Each group will prepare blood spatter from two different angles of impact. Divide the work as follows:

- Group 1: 10 degrees and 50 degrees
- Group 2: 20 degrees and 60 degrees
- Group 3: 30 degrees and 70 degrees
- Group 4: 40 degrees and 80 degrees
To simulate blood being cast off during bleeding, the following process is used.

1. Turn a 5 × 8 index card over so that no lines are visible.
2. Tape two 5 × 8 index cards on the clipboard as shown.
3. Label the cards with your initials on the top-right corner, along with the angle of impact that you will be using.
4. Working with your partners and a roll of masking tape, locate an area along a wall and set up the clipboard as pictured.

![Diagram of clipboard with note cards, wall, floor, and tape with a 10° angle of impact set protractor to 80°.]

5. Start with the first angle assigned. Calculate the protractor setting.
6. From a height of 30 cm drop two drops of blood onto each index card. (See examples of cards on page 233.)
7. While the first card is drying, prepare the second clipboard and card and repeat steps 1 to 6 for the second angle you were assigned.
8. Allow cards to dry completely. Do not move or pick up the cards for at least 30 minutes!
9. Measure the length and width of each droplet in millimeters as indicated in the diagram on page 230. Disregard elongated tails of blood. Measure the main football-shaped or Q-tip rounded area only. If more than one group is assigned the same angle of impact, average your readings for length and width of the drops for the same angle of impact. Record this information in the Data Table on page 233.
10. Determine the R value by dividing the length and width of your blood droplets.
11. Using a calculator and the Law of Sines, determine the actual angle of impact based on your blood-spatter marks.
12. Record all information in the Data Table on page 233.
Examples of blood-spatter patterns 90- to 10-degree angles of impact.

```
<table>
<thead>
<tr>
<th>Expected Impact Angle</th>
<th>Length (mm)</th>
<th>Width (mm)</th>
<th>R=W/L</th>
<th>Actual Impact Angle</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1st Trial</td>
<td>2nd Trial</td>
<td>Average Length</td>
<td>1st Trial</td>
</tr>
<tr>
<td>10°</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20°</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30°</td>
<td></td>
<td></td>
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<tr>
<td>40°</td>
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<td>50°</td>
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<tr>
<td>60°</td>
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<tr>
<td>70°</td>
<td></td>
<td></td>
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<tr>
<td>80°</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>90°</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
```
Questions:
1. How accurate were you in obtaining the desired angles of impact?
2. How would you account for any differences between your actual angle of impact as determined by measuring the length and width of the blood-spatter droplets and your expected angle of impact as determined by your clipboard setup?
3. Provide an example of how knowing the actual angle of impact could help investigators solve crimes.
ACTIVITY 8-5
AREA OF CONVERGENCE

Scenario:
When the police arrived at a crime scene, both the victim and the attackers had already fled. Two areas of blood spatter were the only evidence that an assault had occurred. After drawing lines from the blood spatter, the crime-scene investigator determined not only the direction the blood was traveling and the approximate speed the blood was traveling but also the approximate location where the person was standing when the injury occurred.

Blood-spatter analysis can help investigators reconstruct what happened at a crime scene. When you enter a crime scene, there is always a story waiting to be discovered. An observant crime-scene investigator doesn’t always need eyewitnesses to describe what happened, because the scene always tells the story. You can use blood-spatter analysis to reconstruct what happened at a crime scene.

In this activity, you will analyze blood spatter. By noting the direction of the droplet of blood, you will be able to note the direction in which the blood was moving. The size of the blood spatter will provide some indication of the velocity of the blood when it hit a surface. By examining at least two drops of blood spatter, you will be able to determine where the injured person was located when the injury occurred. When blood-spatter analysis is completed and these factors are determined, it may be possible to reconstruct what happened at the crime scene.

Objectives:
By the end of this activity, you will be able to:
1. Distinguish between blood-spatter droplets and blood-spatter satellites.
2. Distinguish between passive blood spatter and blood spatter that was emitted due to some type of force.
3. Use the shape of the blood droplet to determine the direction in which a drop of blood was moving.
4. Use the position of satellites to determine the direction in which a drop of blood was moving.
5. Use blood spatter to draw the lines of convergence to indicate the position where a person was located when bleeding occurred.

Time Required to Complete Activity: 45 minutes

Materials:
1. ruler
1. colored pencil or marker
1. pencil

Safety Precautions:
None
**Background:**

The shape of an individual drop of blood provides clues to the direction from which the blood originated. A drop of blood that has a circular shape (equal width and length) indicates that the blood fell straight down. When blood falls straight down, such as when it drips from a wound, the angle of impact is 90 degrees. This type of blood spatter is known as passively produced, because no applied force caused the spatter. When a drop of blood is elongated (longer than it is wide), it is possible to determine the direction the blood was traveling when it struck a surface.

The location of the source of blood can be determined if there are at least two drops of blood spatter. By drawing straight lines down the long axis of the blood spatter and noting where the lines intersect, this will indicate the lines of convergence. To determine where the source of the blood originated, draw a small circle around all of the intersecting lines. The intersection of the lines of convergence will indicate in a two-dimensional view the location of the source of the blood.

**Procedure:**

1. For each of the four different blood-spatter patterns pictured (Samples A–D on the next page), you will draw lines of convergence to determine the source of the blood.
2. Determine the direction in which each blood spatter is moving by locating the tail of the blood spatter and any satellites. The satellites will be found ahead of the blood spatter.
3. Draw a line through the middle of the long axis of each of the major drops of blood. Do not draw lines through the satellites.
4. Note: Begin your lines at the leading edge of the drop of blood, and draw the line in the opposite direction from the direction in which the blood was traveling. This will make your diagram easier to read.
5. Draw a small circle around the point where all of the lines intersect using a colored pencil or marker. This is the source of the blood or area of convergence.
6. For each of the four samples, determine how many incidences occurred. See the following example.

**Example**

![Diagram of blood spatter with lines of convergence and a marked source point]

*Drawn correctly!*

Lines are started at the leading edge of the spatter.
Areas of Convergence

Sample A

Sample B

Sample C

Sample D
Note: Circular droplets are formed as blood drops down at a 90-degree angle from a wound and are not considered part of the spatter pattern, but simply a drop.

Questions:

1. Indicate which of these blood-spatter patterns (Sample A, B, C, or D) represents bleeding from:
   a. a bullet wound that caused bleeding as the bullet entered the body and as the bullet passed through the body of one individual
   b. two separate instances of bleeding, possibly from two different individuals
   c. a single wound from one individual
   d. a change in position of a victim after a wound has been inflicted

2. Describe what could have happened in each sample A–D?
   a. How many individuals are involved?
   b. In what direction is movement?
ACTIVITY 8-6
POINT OF ORIGIN

Objectives:
By the end of this activity, you will be able to:
1. Determine the direction of blood flow based on the shape of the droplet.
2. Use lines of convergence to help determine the position of the victim when the wound was inflicted.
3. Calculate the angle of impact for individual drops of blood spatter.
4. Use the Law of Tangents to calculate the height above floor level where the wound was inflicted.

Time Required to Complete Activity: 45 minutes

Materials:
Activity Sheet for Activity 8-6
1 metric ruler
1 colored pencil or marker
1 pencil
calculator with tangent function
tangent tables (optional)

Safety Precautions:
None

Introduction:
In previous activities, you determined the angle of impact and area of convergence for blood spatter. Now you can use that information and the Law of Tangents to calculate the height (position) of the wound, the point of origin, on the individual.

Background:
Blood-spatter analysis helps crime-scene investigators reconstruct what happened at the crime scene. Using only blood-spatter analysis, you may be able to recognize the events leading up to the crime. Although crime-scene investigators may arrive at the crime scene after the victim and witnesses are no longer present, they still need to determine what happened. Often several witnesses give different accounts of the crime. Which witness is providing an accurate description of what really happened?

During the investigation, the crime-scene investigators need to determine if the evidence, in this case the blood spatter, matches the description given by the witnesses, the suspect(s), and the victim(s). In domestic abuse cases, the victim of domestic abuse may tell a false story to try to protect the abusing partner. A victim may state that a head injury occurred as a result of falling down stairs. However, if the blood-spatter patterns are inconsistent with this type of injury, then what type of injury did cause the blood spatter? What actually happened? Is a witness lying? Further investigation is required
when the blood-spatter evidence tells a different story than the witness’s account of the incident.

In this activity, you will analyze blood spatter in three dimensions. By noting the shape of the droplet of blood, you will be able to note the direction in which the blood was moving. The size of the blood spatter will provide some indication of the velocity of the blood when it hit a surface. By examining at least two drops of blood spatter, you will be able to determine where the injured person was located when the injury occurred in two dimensions (lines of convergence). You can easily measure the distance from the area of convergence to the drop of blood. If you want to determine the point of origin, or height from the impact surface, you will need to make some calculations. By measuring the width and length of a single drop of blood, you can determine the angle of impact. By using the Law of Tangents, you can calculate the height from which the blood fell, or the point of origin for the blood.

**Math Review:**

**Right triangle**

- Contains one 90-degree angle.
- The hypotenuse is the longest side of a triangle, opposite the 90-degree angle (right angle).
- The opposite side to an angle is the side directly opposite the angle of interest.
- The adjacent side to an angle is the side closest to the angle that is not the hypotenuse.

**How to use a right triangle and the Law of Tangents in recreating a crime scene:**

**Procedure:**

To recreate a crime scene from several drops of blood, you will need to perform several steps.

1. Determine the direction of blood flow in the drops that follow with an arrow next to the droplet. If the blood drop is circular, then the blood fell at a 90-degree angle. If it is not circular, then the angle of impact was less than 90 degrees. The elongated end of a drop of blood points to the direction in which the blood was moving.
2. From several drops of blood, determine the area of convergence by drawing lines through each of the blood droplets and noting where the lines intersect.
   a. Determine the direction of the blood when it struck an object.
   b. Draw your line in the direction opposite to the direction in which the blood was moving.
   c. The area where the lines intersect represents the area of convergence or the approximate location where the person was located when the blood droplets formed.

3. Once you have determined the area of convergence, you will measure the distance from the area of convergence to the edge of the drop of blood when it first impacted a surface. This distance is indicated in green.

   Recall the diagram of a right triangle. This green line next to the angle of impact is known as the adjacent side.
4. Next determine the angle of impact for each droplet of blood. Select one of the blood droplets and determine the angle of impact for that drop of blood. To calculate the angle of impact, you will need to use the Law of Sines. Remember, when you measure the length of the blood droplet, do not include the thin extension of the leading edge.

\[ \text{Sin of the impact angle} = \frac{\text{width of the blood drop}}{\text{length of the blood drop}} \]

\[ \text{Sin of the angle} = \frac{14}{45} = 0.3111 \]

Determining the inverse sine identifies the impact angle

Angle is 18 degrees

5. Using the Law of Tangents to solve for height. Going back to the right triangle and adding the angle of impact, we can determine the height from where the blood originated. The height of the source of blood is the side opposite the angle of impact. To solve for the height (or the side opposite the angle of impact), we apply the Law of Tangents.

\[ \text{Tangent of an angle} = \frac{\text{Opposite}}{\text{Adjacent}} \]

\[ \text{Origin of blood spatter} \]

\[ \text{Height or the side opposite the angle of impact} \]

\[ \text{Adjacent} \]
Blood and Blood Spatter

Adjacent
Distance from area of convergence to edge of blood spatter

Opposite
or height

Tangent of angle of impact = Opposite/Adjacent = Height/Distance
Solving for Height: Tangent of Angle × Distance = Height

Example:
Crime-scene investigators noted blood spatter on the floor of the kitchen. The investigators drew lines of convergence and measured the distance from the area of convergence to the front edge of a drop of blood. That distance was recorded as 5.75 feet. After measuring the length and width of the blood droplet and using the Law of Sines, it was determined that the angle of impact was 27 degrees. The police wanted to determine the point of origin, or the height from the floor where the person was bleeding.

Solution:
Tan = Opposite/Adjacent = Height/Distance
Tangent of the blood-spatter angle = Height of the wound/Distance from blood to area of convergence
Substituting values in the equation
\[
tan 27^\circ = \frac{\text{Height of wound}}{\text{distance}}
\]
\[
tan 27^\circ = \frac{\text{height}}{5.75 \text{ ft}}
\]
Consult your calculator or tan chart
Problems to Solve:
Make the calculations for each of the following problems and label the right triangle for each blood-spatter drop. Include angle of impact, distance to area of convergence (d), and height (h) above the ground.

Problem 1:
Refer to Blood-spatter Sketch 1. From these drops of blood, determine the point of origin of the blood. To determine the point of origin, you will need to:
1. Determine the direction in which the blood was traveling.
2. Draw lines of convergence.
3. Draw a small circle around the intersection of the lines of convergence to indicate the area of convergence.
4. Measure the distance in millimeters from the area of convergence to the front edge of the blood spatter using a metric ruler.
5. Using the scale of 1 mm = 0.2 feet, determine the actual distance.
6. Using blood droplet 1, determine the angle of impact:
   a. Measure the width and the length of the blood droplet.
   b. Divide the width/length ratio for the blood droplet.
   c. Using a calculator and the inverse sine function, determine the angle of impact for that blood droplet.
7. Using the Law of Tangents, determine the point of origin or the height of the source of blood for droplet 1.

Problem 2:
A 30-year-old man was found shot in the head in his garage. The suspect claims he was being attacked and shot the victim in self-defense. Refer to Blood-spatter Sketch 2 on the next page. From these drops of blood, determine the point of origin of the blood. To determine the point of origin, you will need to:
1. Determine the direction in which the blood was traveling.
2. Draw lines of convergence.
3. Draw a small circle around the intersection of the lines of convergence to indicate the area of convergence.
4. Measure the distance in millimeters from the area of convergence to the front edge of the blood spatter.
5. Use the scale of 1 mm = 0.3 feet to determine the actual distance.
6. Use blood droplet 1 to determine the angle of impact:
   a. Measure the width and the length of the blood droplet.
   b. Divide the width/length ratio for the blood droplet.
   c. Using a calculator and the inverse sine function, determine the angle of impact for that blood droplet.
7. Use the Law of Tangents to determine the point of origin or the height of the source for blood droplet 1.

**Problem 3:**
A victim was found at the foot of a ladder with a chest wound. What is the approximate height of his wound when he was shot? Refer to the blood-spatter sketch below. From these drops of blood, determine the point of origin. To determine the point of origin, you will need to:
1. Determine the direction in which the blood was traveling.
2. Draw lines of convergence.
3. Draw a small circle around the intersection of the lines of convergence to indicate the area of convergence.
4. Measure the distance from the area of convergence to the front edge of the blood spatter (droplet #3) using a millimeter ruler.
5. Use the scale of 1 mm = 1.5 feet to determine the actual distance.
6. Use blood droplet 3 to determine the angle of impact.
   a. Measure the width and the length of the blood droplet.
   b. Divide the width/length ratio for the blood droplet.
   c. Using a calculator and the inverse sine function, determine the angle of impact for that blood droplet.
7. Use the Law of Tangents to determine the point of origin or the height of the source of blood for droplet 3.
ACTIVITY 8-7
CRIME-SCENE INVESTIGATION

Objective:
By the end of this activity, you will be able to:
1. Use information collected from a crime scene and your knowledge of spatter analysis to develop a hypothesis to describe the events that occurred at a crime scene.

Time Required to Complete Activity: 40 minutes

Materials:
- ruler
- pencil
- calculator

Safety Precautions:
None

Procedure:
1. Examine Crime Scene Diagram on page 249 and complete the lines of convergence.
   a. Determine the position of each man at the time of the shootings. Label the position for Man 1 in the diagram. What evidence supports your answer?
   b. Label the position for Man 2 in the diagram. What evidence supports your answer?
2. Both men died. Man 1 was shot through the forehead and died instantly. Man 2 was shot in the stomach and was found dead at the scene as well. Who was shot first? Support your answer with evidence from the crime scene.
3. Data Table 1 contains some of the measurements for the bloodstains found at each position. Complete the table by filling in the blanks.
4. Did your results agree with statements made in question 2? Explain your conclusions.

Questions:
1. Based on your calculations, which man was most likely standing when he was shot? Support your answer with evidence from the crime scene.
2. In position one, there are four bloodstains in front and one bloodstain behind the victim. How do you account for this?
3. Based on the blood-spatter evidence, describe the series of events resulting in the death of these two men. Support your theory with evidence obtained from the blood-spatter analysis.
### Data Table 1

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<th>Stain #</th>
<th>Length of Stain (L) (mm)</th>
<th>Width of Stain (W)(mm)</th>
<th>W/L Ratio (Sine Value)</th>
<th>Angle of Impact (nearest degree)</th>
<th>Distance from Near Edge of Stain (feet)</th>
<th>Tan Value of Angle of Impact (to four decimal places)</th>
<th>Height (h) of Wound above Floor (feet)</th>
<th>h = Tan × distance</th>
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</tr>
</tbody>
</table>

Opposite (height)

Adjacent (distance to stain)

\[
\text{Tan} = \frac{\text{opposite}}{\text{adjacent}}
\]
Crime Scene Diagram

Position 4

Position 1

Position 2

Position 3

Man #1

Man #2

Blood and Blood Spatter