Medium Velocity Spatter Creation
by Mousetraps in a Forensic Science Laboratory

Forensic science encompasses the disciplines of biology, chemistry, mathematics, and physics, which provides an opportunity for students to become engaged in all content areas within one course. The inquiry-based learning environment allows visualization of results almost immediately, facilitating student interest. The laboratory components for a forensics course can be expensive, especially when an apparatus to create medium velocity spatter patterns exceeds one hundred dollars. The following exercise demonstrates how to cheaply create medium velocity blood spatter so students can determine how spatter appears, blood drop directionality and impact angles, and point of origin and point of convergence using rulers, string, and mathematical equations. These determinations will allow students to help recreate a crime scene and determine where a crime was committed. Instructors can use case studies in combination with this exercise to promote critical thinking skills. This exercise would be most appropriate for high school and college students and fits within a two-hour time frame if the materials are prepared in advance.

Materials

The following items are needed for this exercise (per groups of two students):

- 1 wooden Victor® Mouse Trap
- 1 large cardboard box (90 cm L x 90 cm W x 60 cm H–approximate)

or

- 3-4 large pieces of paper (90 cm L x 60 cm W)
- and tape (masking, packing)
- 2 ml synthetic blood (corn syrup, red food coloring, water)

Anna R. Oller

- 1 metric ruler
- 1 ball of string and tape or 1 meter stick
- 1 scientific calculator
- 1 protractor
- 1 straw or pipet
- 2 sets of personal protective equipment (goggles, aprons, gloves)

Procedure

1. A small jar of corn syrup, water, and a bottle of red food coloring can be used to make the blood. Combine approximately 100 ml of corn syrup, 25 ml of water, and 10 drops of red food coloring in a beaker. The mixture can be made to a medium-heavy viscosity which works better since the drops will stay in place and make the exercise more real.

2. The box and paper are used to facilitate easier laboratory cleanup. Most groups will require a six-foot-square area. If boxes are not used, then large pieces of paper taped on the floor and walls will work.

3. Using a straw or pipet, place approximately 1 ml of "blood" on the base area of the trap where the metal will contact the wood. Have a partner hold the back edge of the trap to prevent it from becoming airborne and causing possible injury. Proper precautionary measures should be employed to prevent injury from the trap.

4. Using a pencil or other solid object, gently press on the center of the metal surface to trip the mousetrap. Students can circle and number 10-20 blood drops to further analyze. Calculations can be performed on the drops, which are described below. Figure 1 shows how to perform measurements and calculations.

Anna R. Oller is Associate Professor of Biology at Central Missouri State University, Warrensburg, MO 64093; e-mail: oller@cmsu1.cmsu.edu.
Discussion

Blood Characteristics

Blood is comprised of both liquid and cellular components. The liquid portion found in the circulatory system is called plasma, and the cellular portion contains cells that possess different functions. The different cells found are red blood cells, neutrophils, basophils, eosinophils, monocytes, lymphocytes, and platelets. Red blood cells transport oxygen, carbon dioxide, wastes, hormones, and other components to and from the lungs and tissues. Neutrophils are the first cells that respond to an injury, while eosinophils respond to allergies and parasitic infections. Basophils promote inflammation, and monocytes engulf bacteria. Lymphocytes produce antibodies, and platelets are responsible for blood clotting (Martini, 1998). Blood clotting occurs between five and 15 minutes after exposure to air, but this depends on the amount of blood present, temperature, humidity, exposure to air (wind), and the victim’s condition (aspirin or blood thinner therapy). The clotting time is useful in estimating the time of the crime.

A blood drop is round in shape (a sphere) due to its surface tension. Surface tension pulls surface molecules towards the inside of the sphere, which causes the drop to resist break-up by other forces. Viscosity is the resistance to flow of a liquid, and blood is more viscous (thicker) than water (James & Eckert, 1998). Gravity is the force that pulls everything to the center of the Earth. External forces such as bats, clubs, hammers, or knives act on blood molecules to overcome the physical properties mentioned above.

Spatter

When a blood drop encounters a stopping force, the sphere breaks up and creates extra drops of blood beside the main drop, called spatter. A smooth surface allows the sphere to stay in a circular or elliptical shape, whereas a rough surface like cardboard will create spatter. The size of the blood drop and spatter can be used to determine the approximate velocity of the force applied to the drop.

Spatters greater than 4 mm result from low velocity (<5 feet per second) i.e. activities such as cutting a finger while peeling a potato. Blunt trauma (beatings with hands or clubs) and sharp trauma (stabblings with knives) create medium velocity spatter, which ranges from 1-3 mm in diameter. Medium velocity is usually defined as between 5-25 feet per second, but is technically less than 100 feet per second. Items such as golf clubs and martial art weapons are still classified as medium velocity even though they can create spatter that exceeds 25 feet per second. Running through blood and expiratory blood (blood sprayed when air is exhaled) can also mimic medium velocity spatter. Gunshots create high velocity spatter (a fine spray) of less than 1 mm-diameter drops. High velocity is considered 100 feet per second and faster.

The mousetrap used in this exercise creates medium velocity blood spatter that travels approximately 80 feet per second.

Figure 1.

Blood drop determination of directionality, impact angle, point of convergence, and point of origin.

Directionality

The goal is to determine where a beating occurred, so determining the direction the blood was traveling helps determine the location of the victim at that time. When drops fall straight down onto a smooth surface (i.e. linoleum floor), they will fall slowly, at 90 degrees, and form a circle on impact. When the angle changes, the circle becomes elongated into an ellipsoid. Thus, a tail (looks like an exclamation point) can be seen at angles other than 90 degrees to show directionality of the blood. The tail (exclamation point) "points" to the direction the drop was moving.

Angle of Impact

The angle of impact is important in determining the point of origin and point of convergence in order to determine where a beating occurred. In order to determine the angle of impact, a metric ruler and scientific calculator are needed. The length of the drop and the width of the drop both need to be recorded. If the drop is uneven or was smeared, the end of the drop may need to be rounded off (use a pencil to make a line where the drop should end) to accurately perform calculations. Using a calculator, the width is divided by the length and the sin symbol (θ) is pressed. Depending on the calculator, the shift or second function key may need to be pressed first. The number calculated is the angle in degrees. A ratio of 1 equals 90 degrees and a ratio of 0.5 equals 30 degrees. A protractor can be used to help show students at what angle the blood drop was traveling.

Point of Convergence

The point of convergence is where the blood spatter would come together if the lines were all connected to form one point. This allows students to determine where
the blood came off an object. Pieces of string can be cut and taped to the paper, or a ruler can be used to draw straight lines and determine where the lines all come together. This provides a two-dimensional (X and Y axis) viewing of the scene to determine where in the room the beating occurred. Students should measure the distance of the drops from the point of convergence for calculating the point of origin.

Point of Origin

The point of origin will provide a three-dimensional (X, Y, Z axis) viewing so one can determine at what height the crime was committed. This is based upon a straight line rather than a parabola, so the calculations will give you a maximum height. Spatter close to the target surface will give a projected point of origin that is more closely related to the actual origin (James & Eckert, 1998). The tangent of the impact angle should be multiplied by the distance from the point of convergence to obtain the point of origin.

Advantages & Disadvantages

Advantages of using this exercise include being able to create an inquiry-based learning module that encompasses biology, chemistry, physics, and mathematical skills. Students experience firsthand how to measure blood drops, and how to calculate several important details involved in investigative research. Each group calculates different results so students will understand that several correct answers are obtainable. Students can further manipulate the origin (place trap on a stool or desk) to make the activity more investigative. Active learning helps students retain information and promotes life-long learning.

One disadvantage of this exercise is that the mouse-trap will most likely jump into the air when it is triggered if the partner does not stabilize the trap. Therefore, the convergence can be difficult to determine, and spatter may be found where one did not expect. Another disadvantage is the potential for an expansive cleanup (ten feet beyond the trap) of the room if students are left without proper supervision. Of course, working with mousetraps can cause injury if the metal bracket lands on a hand in the wrong position while trying to set or trip the trap, or if personal protective equipment is not used.

My students cited this as their favorite laboratory exercise of the semester. The exercises are engaging and encourage collaborative learning between laboratory partners. Students appear to retain much more of this information than from a lecture. The mousetrap is a cheap and effective tool for engaging students in multidisciplinary techniques incorporated into a forensic science laboratory.

References