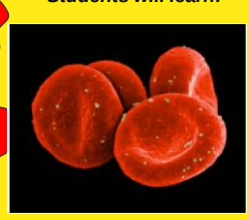
Blood and Blood Splatter

"Out damned spot! Out, I say
Here's the smell of the blood still,
All the perfumes of Arabia will not
Sweeten this little hand. Oh, Oh, Oh!"

—William Shakespeare's Lady Macbeth, in Macbeth

Blood

Students will learn:



- That an antibody and an antigen of different types will agglutinate, or clump, when mixed together.
- That the significance of the evidence depends on a characteristic's relative occurrence in the population.

Blood

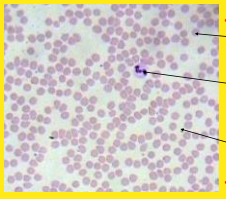
Students will be able to:

- Determine whether a stain is blood.
- Determine whether a bloodstain is human or animal blood.
- Determine the blood type of a simulated bloodstain using the ABO/Rh system.
- Explore bloodstain patterns as a function of velocity, direction, and height of fall.
- Use technology and mathematics to improve investigations and communications.

Serology

Serology is the examination and analysis of body fluids. A forensic serologist may analyze a variety of body fluids including saliva, semen, urine, and blood. From 1950 to the late 1980's, forensic serology was a most important part of lab procedures. With the development of DNA techniques, more time, money, and significance was placed in developing DNA labs. However, with limited funds and the time required for DNA testing, most labs still use many of the basic serology testing procedures.

Blood Characteristics



- Plasma is the fluid portion of the blood **(55%)**
- Cells (45%)
  - Erythrocytes are red blood cells. They are responsible for oxygen distribution.
  - Leukocytes are the white blood cells; they are responsible for "cleaning" the system of foreign invaders.
  - Thrombocytes or platelets are responsible for blood clotting
- Serum is the liquid that separates from the blood when a clot is formed.

Historical Perspective of Blood Typing

Around 1900, Karl Landsteiner discovered that there are four different types of human blood based on the presence or absence of specific antigens found on the surface of the red blood cells.

In 1940, Landsteiner and Weiner reported the discovery of the Rh factor by studying the blood of the Rhesus monkey. 85% of Caucasians, 94% of Black Americans and 99% of all Asians are Rh positive.

Blood Terminology

- **ABO blood groups**—based on having an A, B, both or no antigens on red blood cells
- **Rh factor**— may be present on red blood cells; positive if present and negative if not
- **Antigen**— a substance that can stimulate the body to make antibodies. Certain antigens (proteins) found in the plasma of the red blood cell's membrane account for blood type.
- **Antibody**—a substance that reacts with an antigen
- **Agglutination**— clumping of red blood cells; will result if blood types with different antigens are mixed

Unknown Stain at a Scene

Questions to be answered:

- Is it blood?
- Is it human blood?
- Whose is it?
  - Determine blood type, alcohol content, drugs present
  - Determine the method(s) in which blood may have been deposited

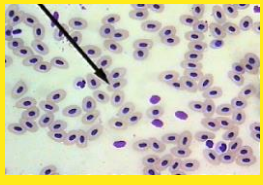
Presumptive Tests for Blood Determination

- **Kastle-Meyer color test**—a mixture of phenolphthalein and hydrogen peroxide; the hemoglobin will cause the formation of a deep pink color if blood is present
- **Hematest® tablet**—reacts with the heme group in blood causing a blue-green color
- **Luminol test**—reaction with blood to produce light

Human vs Animal Blood

- **Microscopic observation**
- **Precipitin test**—blood is injected into a rabbit; antibodies are formed; the rabbit's blood is extracted as an antiserum; the antiserum is placed on sample blood. The sample will react with human proteins if human blood is present. This test is very sensitive and requires only a small amount of blood.

Animal Blood

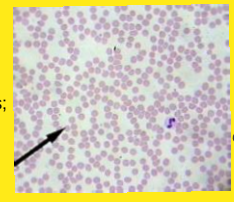


Larger nucleic red blood cells

Frog Blood

Human Blood

- Red blood cells are most numerous; 5 to 6 million per mm^3
- White blood cells are larger and less numerous; 5 to 10,000 per mm^3
- Platelets are tiny, cellular fragments; 350 to 500,00 per mm^3



Blood Typing

- Blood type A has antigen A on the surface of the cell and will agglutinate with blood type B.
- Blood type B has antigen B on the surface of the cell and will agglutinate with blood type A.
- Blood type AB has antigens A and B on the surface of the cells and will not agglutinate with either type A or B blood.
- Blood type O has neither antigen A or B and will not agglutinate.

Blood Groups

Type	Antigen	Antibody	Can Give Blood To	Can Get Blood From
A	A	B	A, AB	O, A
B	B	A	B, AB	O , B
AB	A and B	Neither A nor B	AB	A, B, O, AB
O	Neither A nor B	A and B	A, B, O, AB	O

Population Distribution of Blood Types in the U.S.

Type	Percent
A	42
B	10
AB	3
O	45

Blood Pattern Reconstruction

Scene Pattern Reconstruction

1. Stain condition
2. Pattern
3. Distribution
4. Location
5. Directionality

Lab Results Reconstruction

1. Genetic marker typing
2. Age Determination
3. Source Determination
4. Race Determination
5. Sex Determination

—From "Cracking Cases" by Dr. Henry C. Lee

Blood Spatter Evidence

A field of forensic investigation which deals with the physical properties of blood and the patterns produced under different conditions as a result of various forces being applied to the blood. Blood, as a fluid, follows the laws of physics.

People of Historical Significance

Paul Kirk (1902-1970) was a professor of criminalistics and biochemistry at Berkeley in California. He actively assisted law enforcement organizations from 1935 to 1967. His book, *Crime Investigations*, contained a chapter in which he discussed the application of blood stain pattern analysis to criminal investigations. Dr. Kirk analyzed the blood stain pattern photos from the Sam Sheppard case and was instrumental in Sheppard's release at his second trial. Find out more about the case at Courttv's crime library.

Blood Droplet Characteristics

- A blood droplet will remain spherical in space until it collides with a surface
- Once a blood droplet impacts a surface, a bloodstain is formed.
- A droplet falling from the same height, hitting the same surface at the same angle, will produce a stain with the same basic shape.
- How will the shape change as the height is increased or decreased?

Blood Droplet Volume

- A droplet contains approximately 0.05 cc of fluid
- Is not the same for all blood droplets, but is generally from 0.03 cc to 0.15 cc
- Is directly dependent upon the surface or orifice from which it originates
- The impact area is called the target.

Conditions Affecting Shape of Blood Droplet

- Size of the droplet
- Angle of impact
- Velocity at which the blood droplet left its origin
- Height
- Texture of the target surface
  - On clean glass or plastic—droplet will have smooth outside edges
  - On a rough surface—will produce scalloping on the edges

Questions Answered by Blood Spatter Interpretation

- The distance between the target surface and the origin of blood
- The point(s) of origin of the blood
- Movement and direction of a person or an object
- The number of blows, shots, etc. causing the bloodshed and/or the dispersal of blood.
- Type and direction of impact that produced the bloodshed
- The position of the victim and/or object during bloodshed
- Movement of the victim and/or object after bloodshed

Bloodstain Terminology

- **Angle of impact**—angle at which blood strikes a target surface.
- **Bloodstain transfer**—when a bloody object comes into contact with a surface and leaves a patterned blood image on the surface
- **Backspatter**—blood that is directed back toward the source of energy
- **Cast-off**—blood that is thrown from an object in motion

Bloodstain Terminology

- **Contact stain**—bloodstains caused by contact between a wet blood-bearing surface and a second surface which may or may not have blood on it
  - **Transfer**—an image is recognizable and may be identifiable with a particular object
  - **Swipe**—wet blood is transferred to a surface which did not have blood on it
  - **Wipe**—a non-blood bearing object moves through a wet bloodstain, altering the appearance of the original stain

Bloodstain Terminology

- **Directionality**—relates to the direction a drop of blood traveled in space from its point of origin
- **Terminal velocity**—the greatest speed to which a free falling drop of blood can accelerate in air. It is dependent upon the acceleration of gravity and the friction of the air against the blood—approximately 25.1 feet/second.
  - **High velocity**—greater than 25 feet per second, usually 100 feet per second; gives a fine mist appearance
  - **Medium velocity**—5 to 25 feet per second
  - **Low velocity**—5 feet per second or less

Bloodstain Patterns

The shape of a blood drop:

- **Round**—if it falls straight down at a 90 degree angle.
- **Elliptical**—blood droplets elongate as the angle decreases from 90 to 0 degrees; the angle can be determined by the following formula:

$$\text{impact angle} = \sin^{-1}(\arcsin)\ \frac{\text{width}}{\text{length}}$$

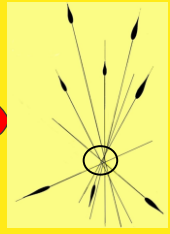
Impact

- The more acute the angle of impact, the more elongated the stain.
- 90 degree angles are perfectly round drops with 80 degree angles taking on a more elliptical shape.
  At about 30 degrees the stain will begin to produce a tail.
- The more acute the angle, the easier it is to determine the direction of travel.

Bloodstain Patterns

- The harder and less porous the surface, the less the blood drop will break apart.
- The softer and more porous the surface, the more a blood drop will break apart.
- The pointed end of the blood stain faces the direction of travel.

Area of Intersection and Convergence



The location of the blood source can be determined by drawing lines from the various blood droplets to the point where they intersect.

The area of convergence is the point of origin; the spot where the "blow" occurred. It may be established at the scene with measurement of angles by use of strings.

Blood Evidence

- Class evidence for blood would include blood type. If you can determine the DNA you would have individual evidence.
- Blood stain patterns are considered circumstantial evidence in a court room. Experts could argue many points including direction of travel, height of the perpetrator, position of the victim, left/right hand, whether the body was moved, etc.

Secretors

80% of the population are secretors. Their blood-type antigens are found in high concentration in their body fluids such as saliva, semen, vaginal secretions and gastric juice.

People in the News

Herbert L. MacDonell is considered by many as the father of modern bloodstain pattern analysis. He is the director of the Lab of Forensic Science and founder of the Bloodstain Evidence Institute (1973) in Corning, NY. His work, *Bloodstain Pattern Interpretation*, helped to jump start this discipline. He has consulted on criminal cases in all 50 states, in addition to testifying in the O.J. Simpson trial and in the assassination cases of Sen. Robert F. Kennedy and Dr. Martin Luther King Jr.

More about Serology

For additional information about blood evidence, and famous crimes that involves serology, check out Court TV's Crime Library at:

www.crimelibrary.com/criminal_mind/forensics/serology/1.html