BLOOD AND BLOOD SPATTER ANALYSIS

I. Composition of Blood

Blood is a circulating tissue consisting of three types of cells: **RED** blood cells, **WHITE** blood cells, and **PLATELETS**. These cells are suspended in a liquid known as **PLASMA**. Plasma is similar to **SALT** water in composition. It carries dissolved proteins, such as antibodies, hormones, and clotting factors,

and nutrients such as glucose, amino acids, salts, & minerals.

A. Blood Cells

Each blood cell performs a different function.

- Red Blood Cells: carry the gases **OXYGEN** and **CARBON DIOXIDE**
- Hemoglobin in red blood cells is responsible for transporting **OXYGEN** to cells and for the **RED** color of blood

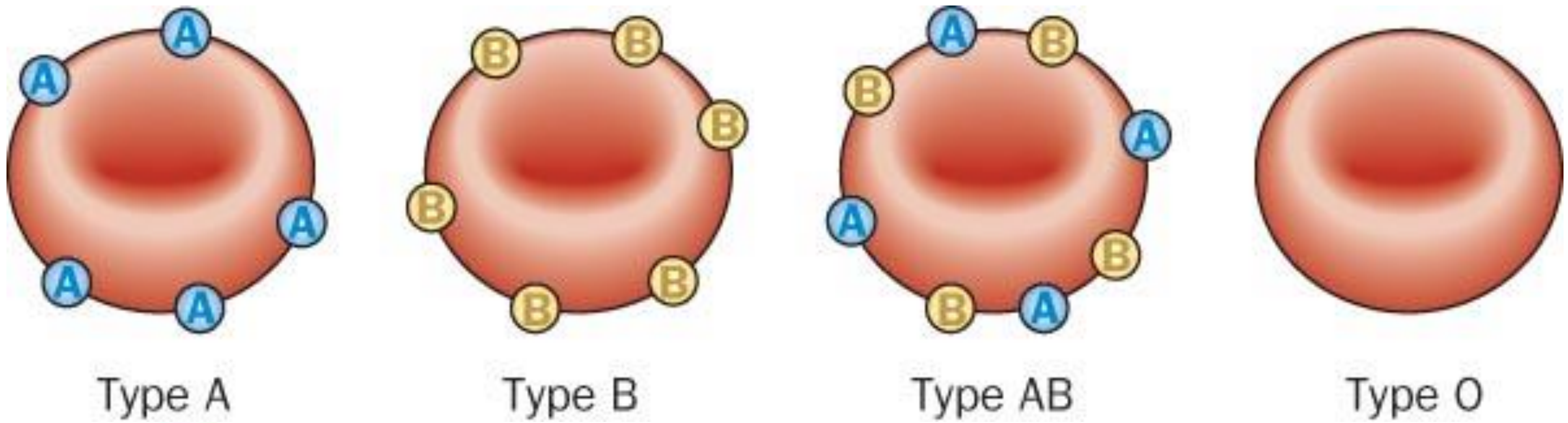
- White Blood Cells: Fight **DISEASE** and **FOREIGN INVADERS**
- Antibodies: **PROTEINS** which assist in the immune response (fighting bacteria, viruses, parasites)
- Platelets: aid in blood **CLOTTING** and are involved in repairing damaged blood **VESSELS**

B. Blood Typing

Because many different people share the same type of blood, blood evidence is considered to be **CLASS** evidence. By typing the blood found at a crime scene, it is possible to line a suspect to a crime scene or to exclude a suspect. However, matching blood types does NOT prove guilt.

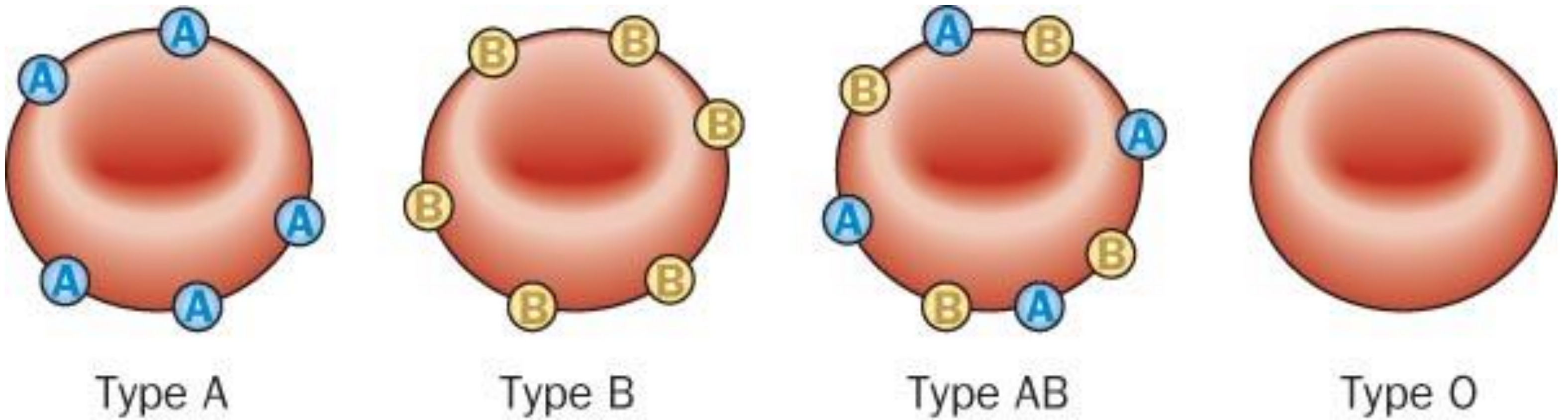
1. A and B Proteins

A and B proteins are found on the **SURFACE** of some red blood cells.



IF A PERSON'S BLOOD CONTAINS:

- PROTEIN A - HE/SHE HAS TYPE A BLOOD
- PROTEIN B - HE/SHE HAS TYPE B BLOOD.
- BOTH PROTEIN A AND B - HE/SHE HAS TYPE AB BLOOD.
- LACKS PROTEIN A AND B - HE/SHE HAS TYPE O BLOOD.



2. Rh factor

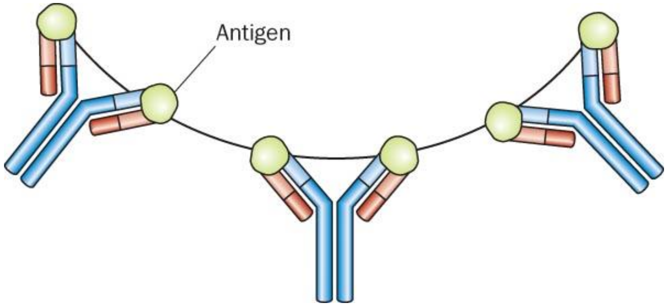
This is another type of protein associated with the red blood cells.

- 85% of the human population has a protein called Rh factor on their red blood cells.
- Blood that has the Rh factor is designated **Rh+** while blood that does not have this factor is **Rh-**.

3. Antibodies

White blood cells identify foreign proteins and secrete antibodies. The antibodies are **Y-shaped** protein molecules that bind to the molecular shape of an **ANTIGEN**, fitting like a puzzle.

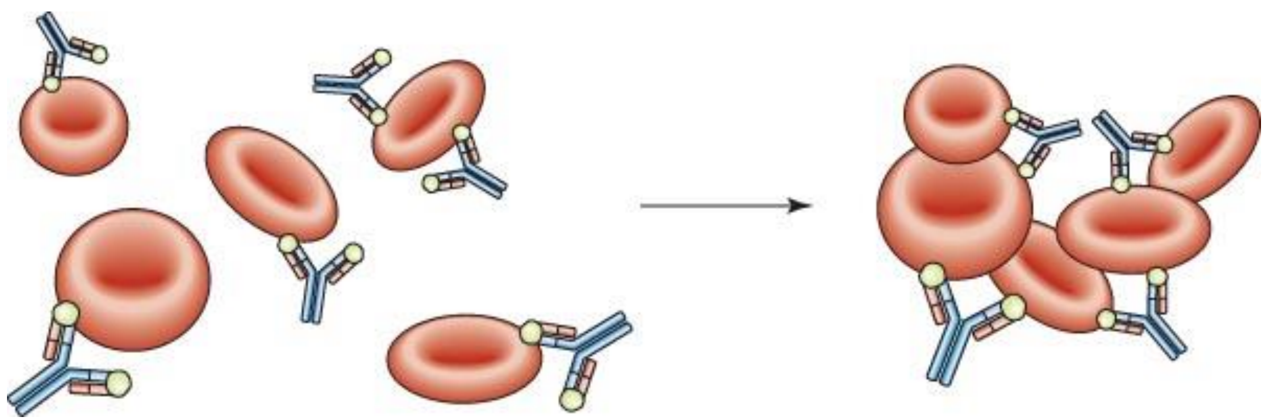
When a foreign invader is recognized, an attack is launched. This is called the **ANTIGEN-ANTIBODY** response.



4. Agglutination

This is the **CLUMPING** of the red blood

ells when the arms of the Y-shaped antibody attach to the red blood cells.



5. Blood Typing Tests

Blood typing is a way to identify and match blood samples. When blood is tested and types, the presence of three red blood cell proteins are looked for: **A, B and Rh**

C. Probability and Blood Types

Given the frequency of different genes within a population, it is possible to determine the probability or chance that a particular blood type will appear within a particular population.

ABO

Type	Percent	Fraction
A	42%	42/100
B	12%	12/100
AB	3%	3/100
O	43%	43/100

MN

Type	Percent	Fraction
MM	30%	30/100
MN	48%	48/100
NN	22%	22/100

Rh

Type	Percent	Fraction
Rh +	85%	85/100
Rh–	15%	15/100

What percentage of the population would have Type A+ blood?

Type A = 42% → 42/100 = 0.42
Rh+ = 85%→ 85/100 = 0.85

0.42 x 0.85 = 0.357 x 100 = 35.7%

36/100 people are A+ blood

What percentage of the population would have Type O-, MN?

Type O = 43% → 43/100 = 0.43
Rh- = 15%→ 15/100 = 0.15
MN = 48% → 48/100 = 0.48

0.43 x 0.15 x 0.48 = 0.03096 x 100
= 3.1%

3/100 people have this blood

Detection of Blood at the Crime Scene

Red blood cells contain hemoglobin, the iron- bearing protein that carries oxygen.

To detect hemoglobin, an investigator mixes **LUMINOL** powder with **HYDROGEN PEROXIDE** in a spray bottle. The mixture is then sprayed on the area to be examined for blood.

The **IRON** from the hemoglobin, acting as a catalyst, speeds up the reaction. As the reaction progresses, **LIGHT** is generated for about 30 seconds on the surface of the blood sample.

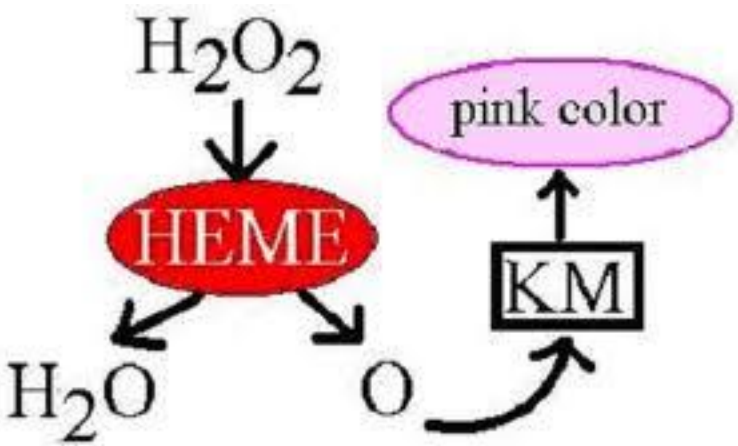
If an object or objects have what *appears* to be blood on them, the forensic technician will NOT test directly on the stain. WHY??

Method for obtaining a sample of alleged blood stain:

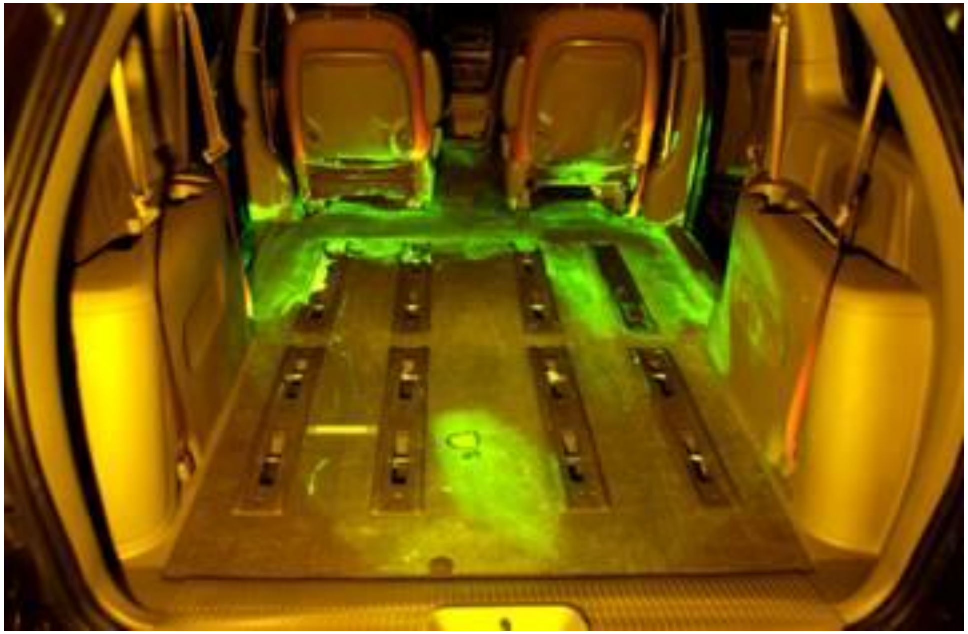
1. Obtain a sterile, dry cotton swab(s)
2. Moisten with distilled water
3. Rub swab across stain several times to transfer evidence
4. Place in a sterile plastic or glass container until further analysis.

1. Confirm the stain is blood.

• Kastle-Meyer test: If blood is present, a dark **PINK** color is produced.



- Leukomalachite green: This chemical undergoes a color change, producing a **GREEN** color in the presence of blood.

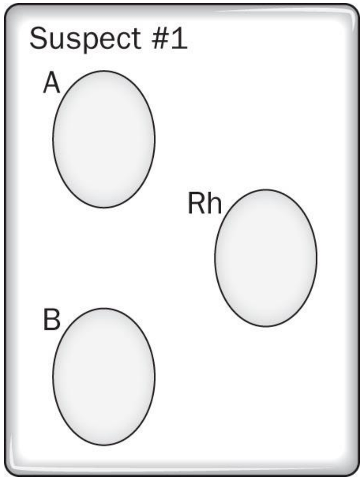


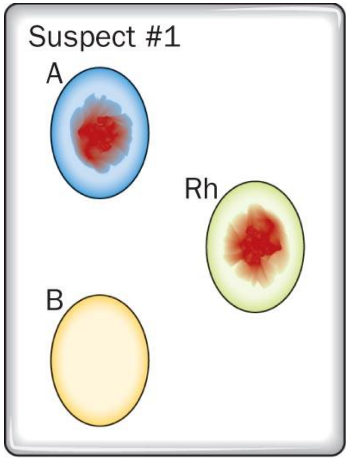
2. Confirm the blood is human.

ELISA test : involves an **ANTIBODY- PROTEIN** reaction. Human blood is injected into a small animal to produce antibodies against human blood. These antibodies are isolated and stored. When a sample of human blood is mixed with some of these anti-human antibodies, a positive reaction will occur, and the presence of human blood is confirmed.

3. Determine blood type.

Blood collected from a crime scene is tested using specific antibodies. The person's blood type is determined by examining antigen–antibody reactions. Remember, the resulting match is considered <u>CLASS</u> evidence. However, if the blood does not match, then a particular person may be excluded as a suspect.



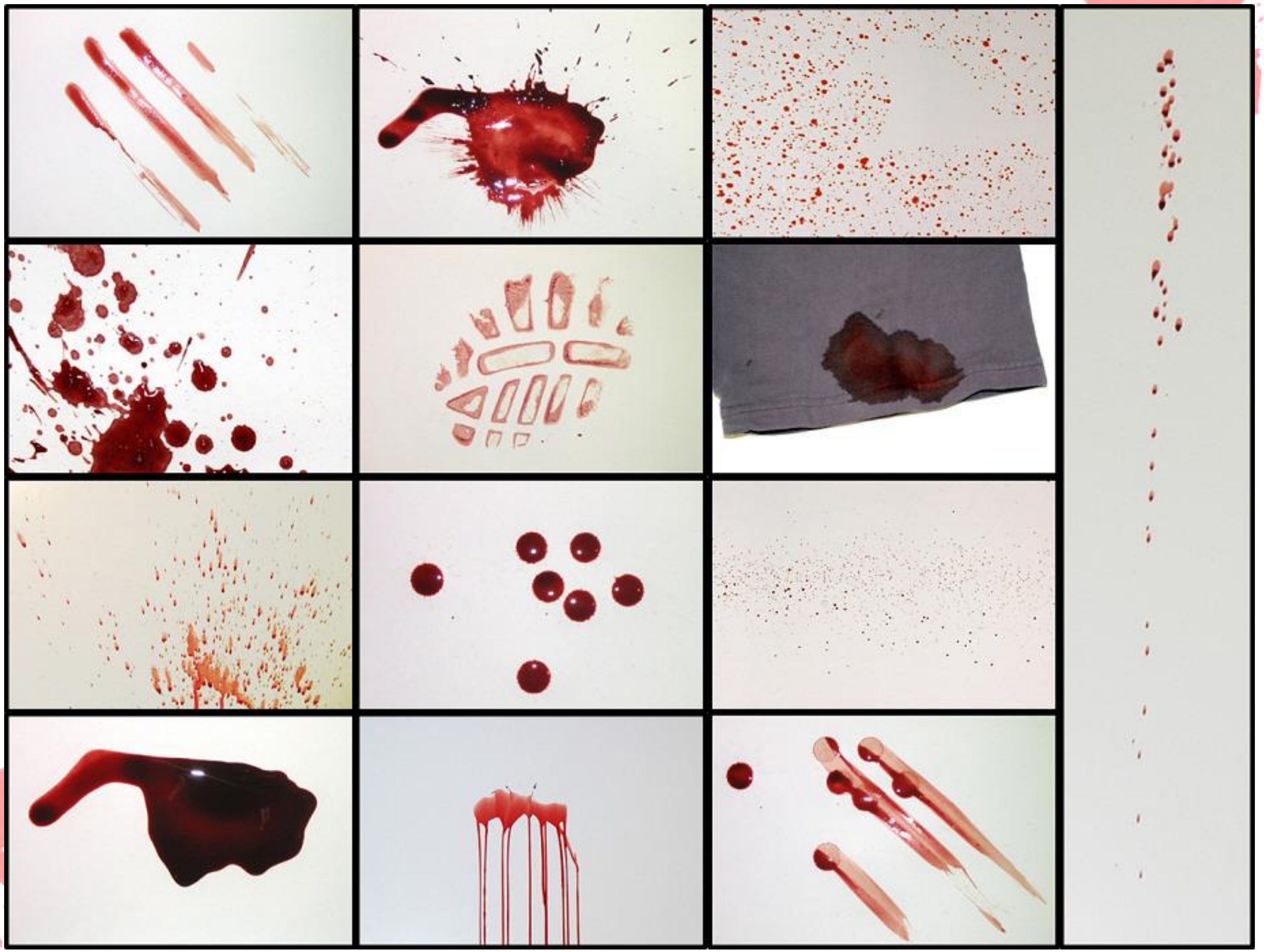


Type A+

4. Gathering DNA evidence

Restriction Fragment Length Polymorphism (RFLP) DNA analysis/testing is commonly statistically individualizing (one out of several million or several billion) and it has withstood rigorous court challenges on its validity. The limits however, is that this method also usually requires a LARGE sample size to obtain significant results.

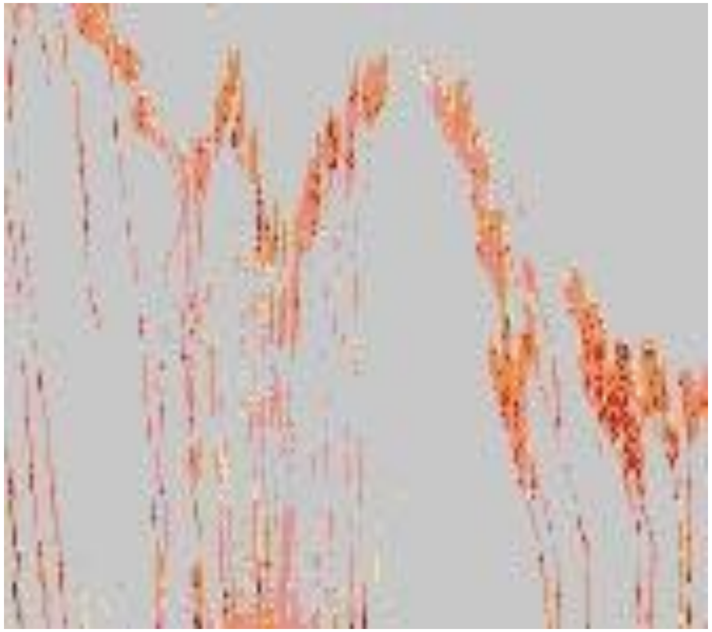
Blood Spatter Patterns



There are six patterns into which blood spatters can be classified

1. Blood falling directly to the floor at a 90-degree angle will produce circular drops, with secondary satellites being more produced if the surface hit is textured. This is known as a **PASSIVE** fall.

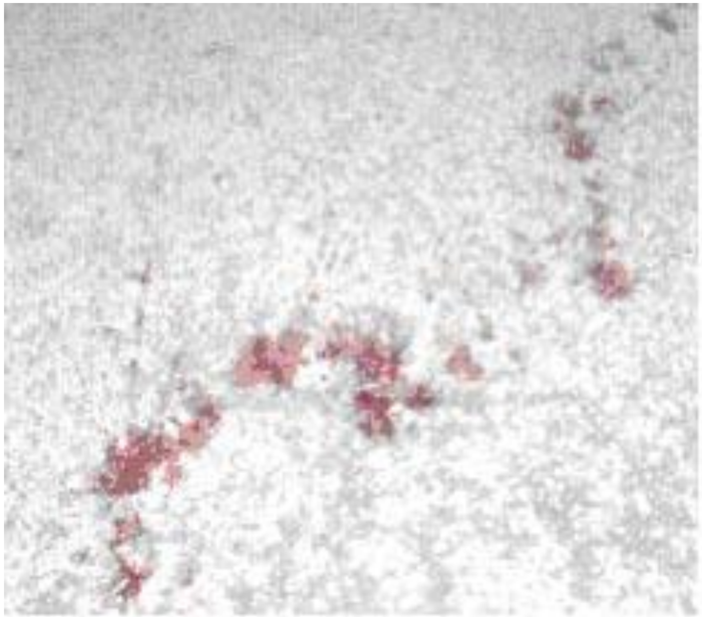
2. <u>**ARTERIAL**</u> spurts or gushes typically found on walls or ceilings are caused by the pumping action of the heart.



3. **SPLASHES** are shaped like exclamation points. The shape and position of the spatter pattern can help locate the position of the victim at the time of the attack.

4. **SMEARS** are left by a bleeding victim depositing blood as he or she touches or brushes against a wall or furniture.

5. <u>**TRAILS**</u> of blood can be left by a bleeding victim as he or she moves from one location to another. The droplets could be round or smeared or even appear as spurts.

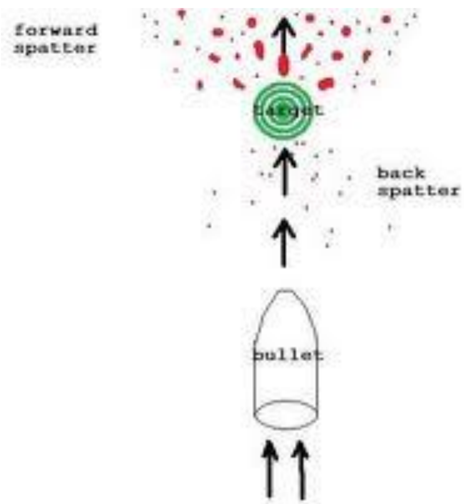


6. **POOLS** of blood form around a victim who is bleeding heavily and remains in one place.

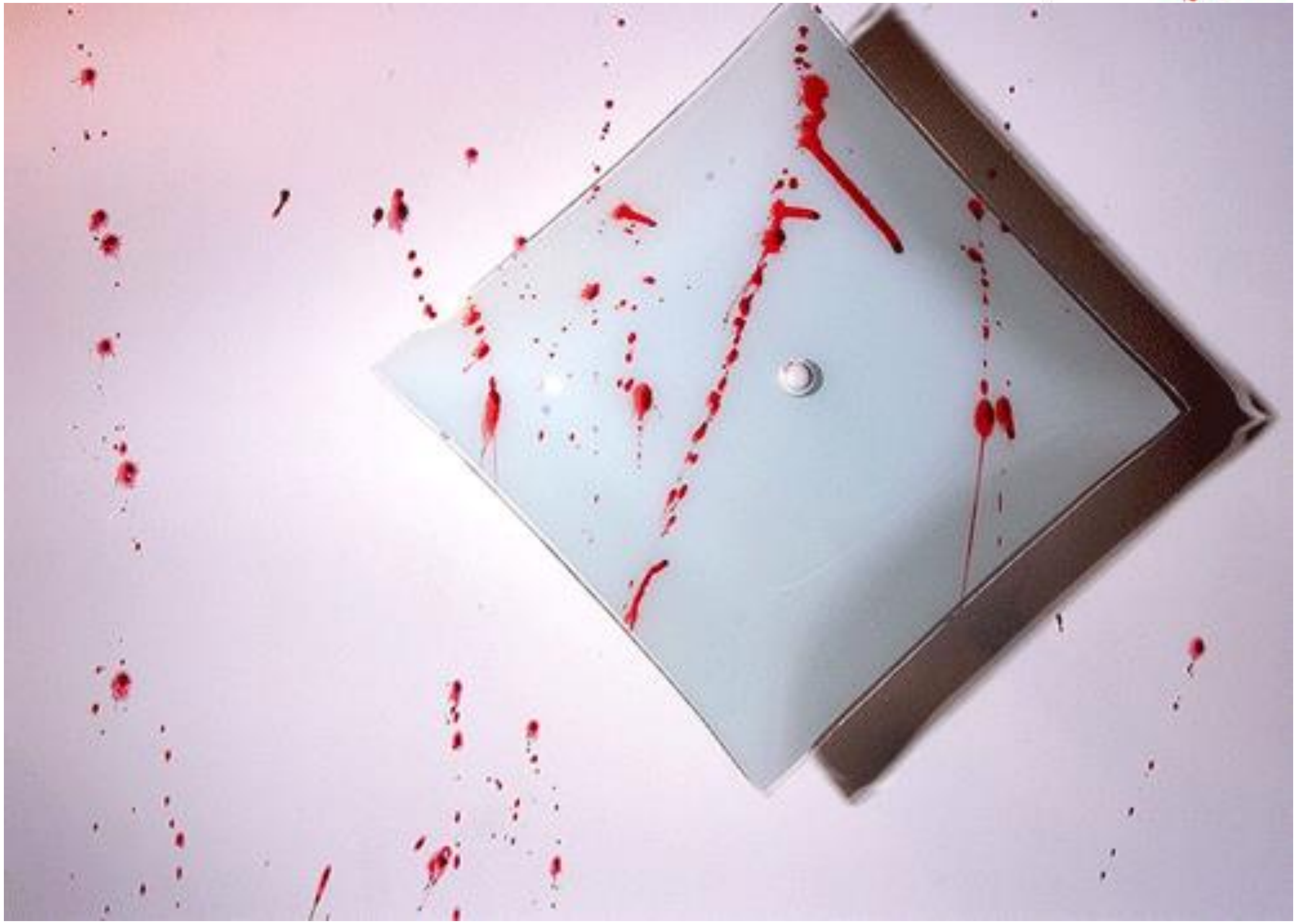
If the bleeding victim moves to another location, there may appear to be droplets or smearing connecting the first location with a second.

Spatter patterns can help the investigator determine the type of wound and impact (weapon) that caused an injury.

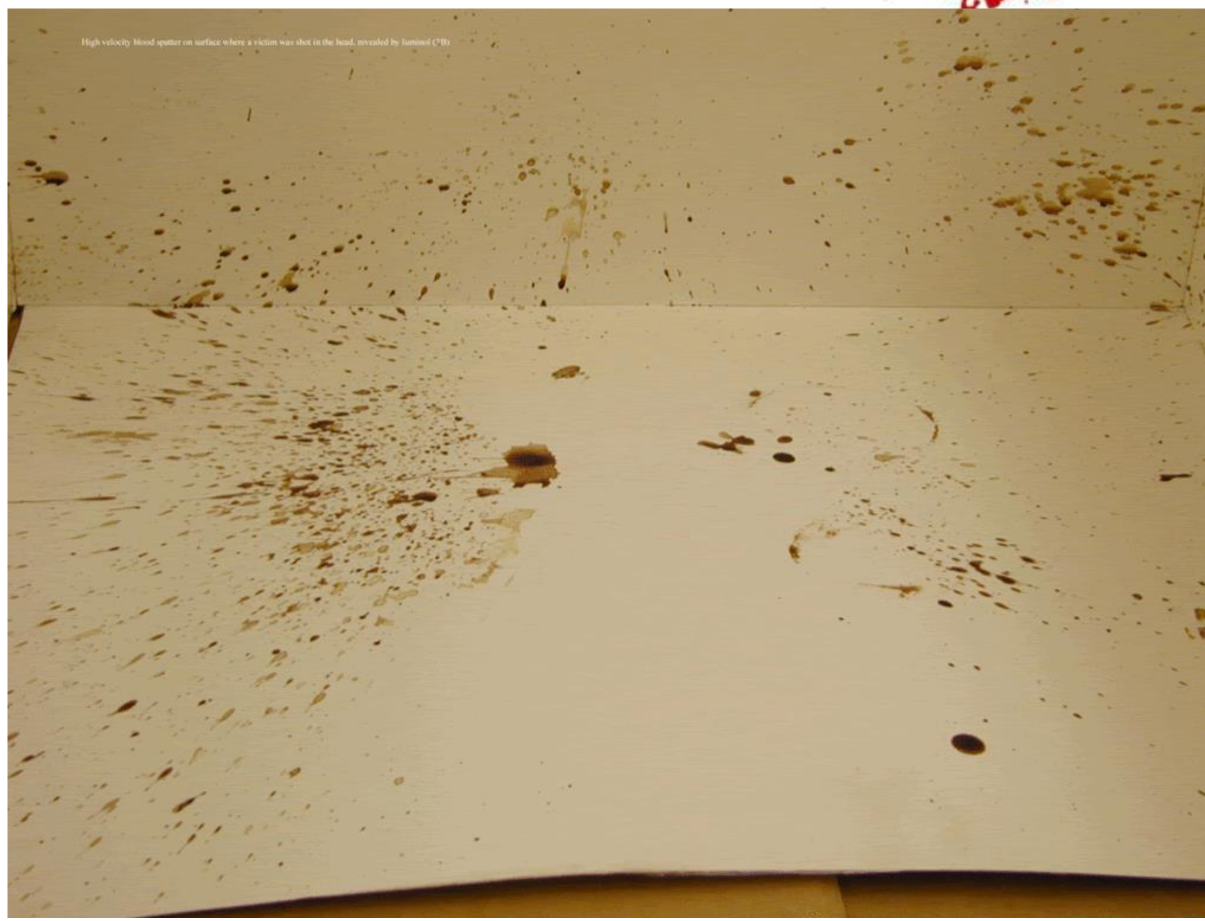
- A **FINE-MIST** spatter pattern is produced by a high-velocity impact, such as a gunshot wound



A low velocity impact (such as a beating with a baseball bat) will produce blood spatter with a **LARGER** spatter pattern.



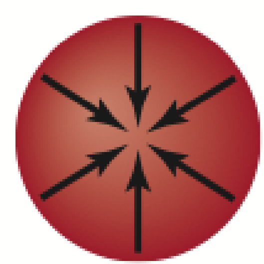
Voids (empty spaces) in the spatter pattern could help determine the presence of a person or object **MOVED** after the attack.



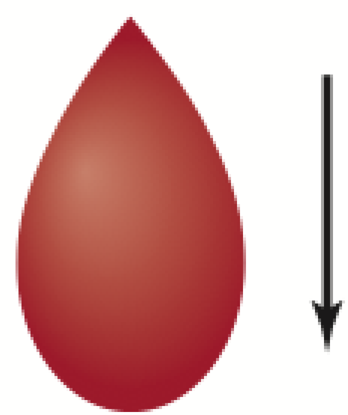
Blood Spatter Analysis

Recall that blood is a thick mixture of blood cells and plasma. Due to the chemical and physical makeup, blood is **COHESIVE**. This means that blood mixture is attracted to similar blood mixtures and tends to **STICK** together and not separate as it falls.

Cohesive forces



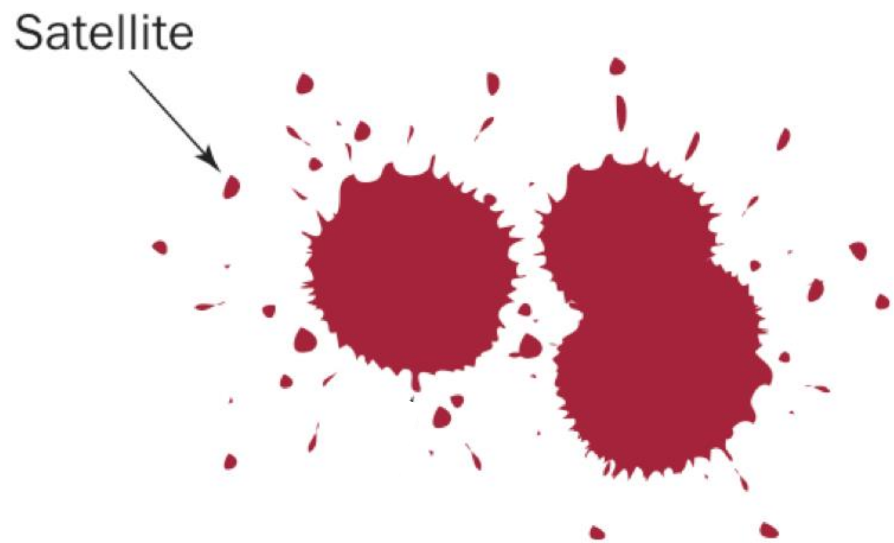
When a person is injured and bleeding, **GRAVITY** acts on blood, pulling it downwards. Due to the cohesive nature of blood, it maintains a **ROUND** appearance as it travels through the air.



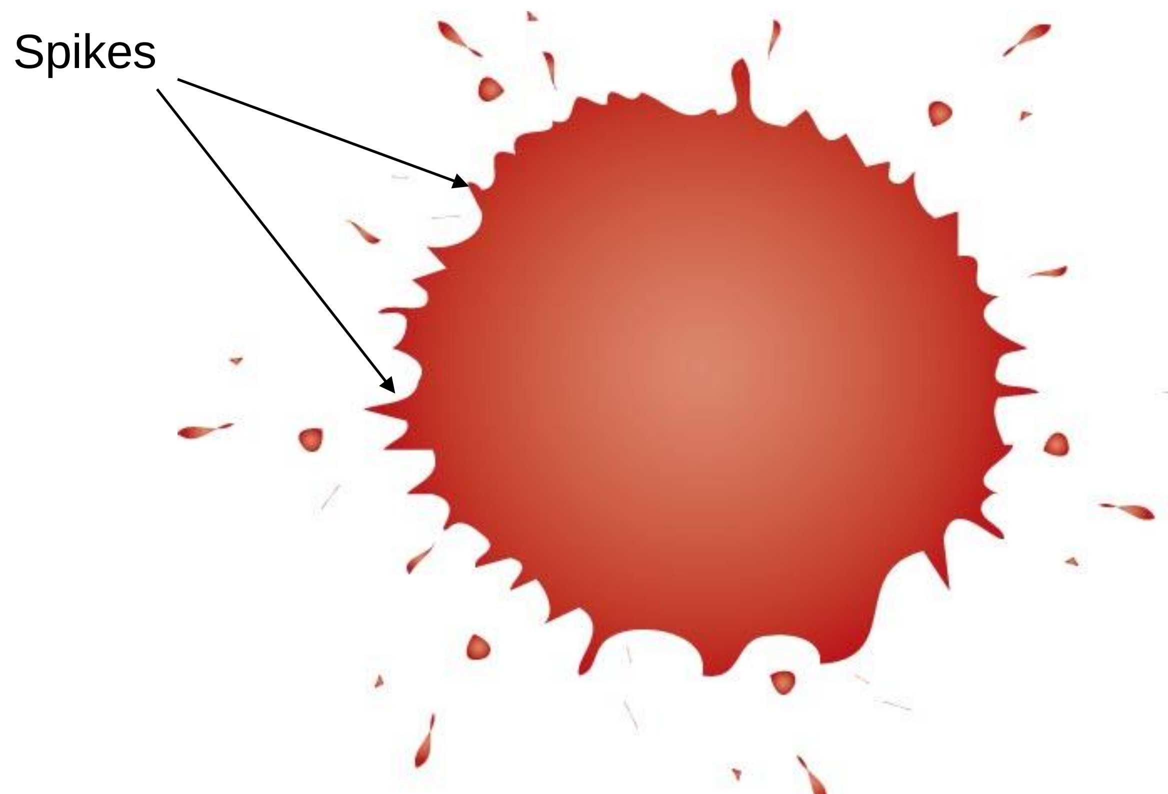
A falling drop of blood

The effect of gravity

When a drop of blood falls on a flat surface, the blood drop will have a **ROUND** appearance. However, if any of the blood does overcome cohesion, it will form secondary droplets known as **SATELLITES**.



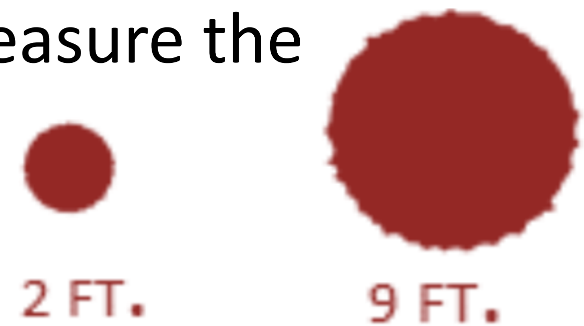
If blood lands on a porous surface, then the edge of the drop of blood may form small **SPIKES** or **EXTENSIONS**.



Determining the HEIGHT from which blood fell

When trying to determine the distance (height) blood fell from, it is important to measure the **DIAMETER** of the blood stain.

- The **LARGER** and **WIDER** the blood drop, the higher the height that the blood fell from



The greater the presence of **SPIKES** and **SATELLITES**, the higher the height that the blood fell from

Determining the DIRECTION of blood movement

The shape of an individual drop of blood provides clues to the direction from where the blood originated. A **CIRCULAR** drop of blood indicates that the blood fell straight down.

But, when a blood drop is **ELONGATED** (longer than it is wide), it is possible to determine the direction the blood was traveling when it struck a surface.

As moving blood strikes a surface,
several forces affect the droplet of blood.
These forces are cohesion and adhesion

- Cohesion is an attractive force between two **SIMILAR** substances.

- Adhesion is a force between two **UNLIKE** surfaces, such as blood and the surface of a wall.

When blood comes into contact with another surface, the blood tends to **<u>STICK</u>** to it.

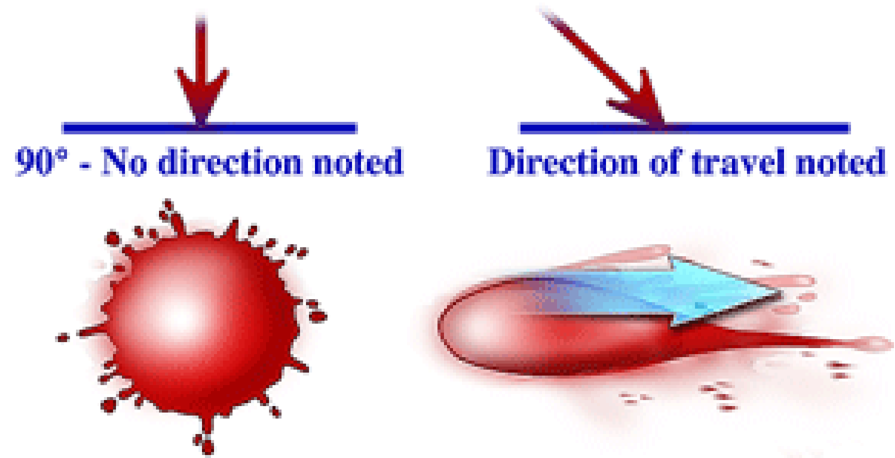
As a result, the point of impact may appear to be **<u>DARKER</u>** and **<u>WIDER</u>** than the rest of the drop of blood spatter.

MOMENTUM tends to keep the blood moving

In the direction it was traveling. As blood droplets move away from their source,

the blood droplet **ELONGATES** and may produce a thinner **TAIL - LIKE** appearance.

- The tail points in the **DIRECTION** of blood's movement.



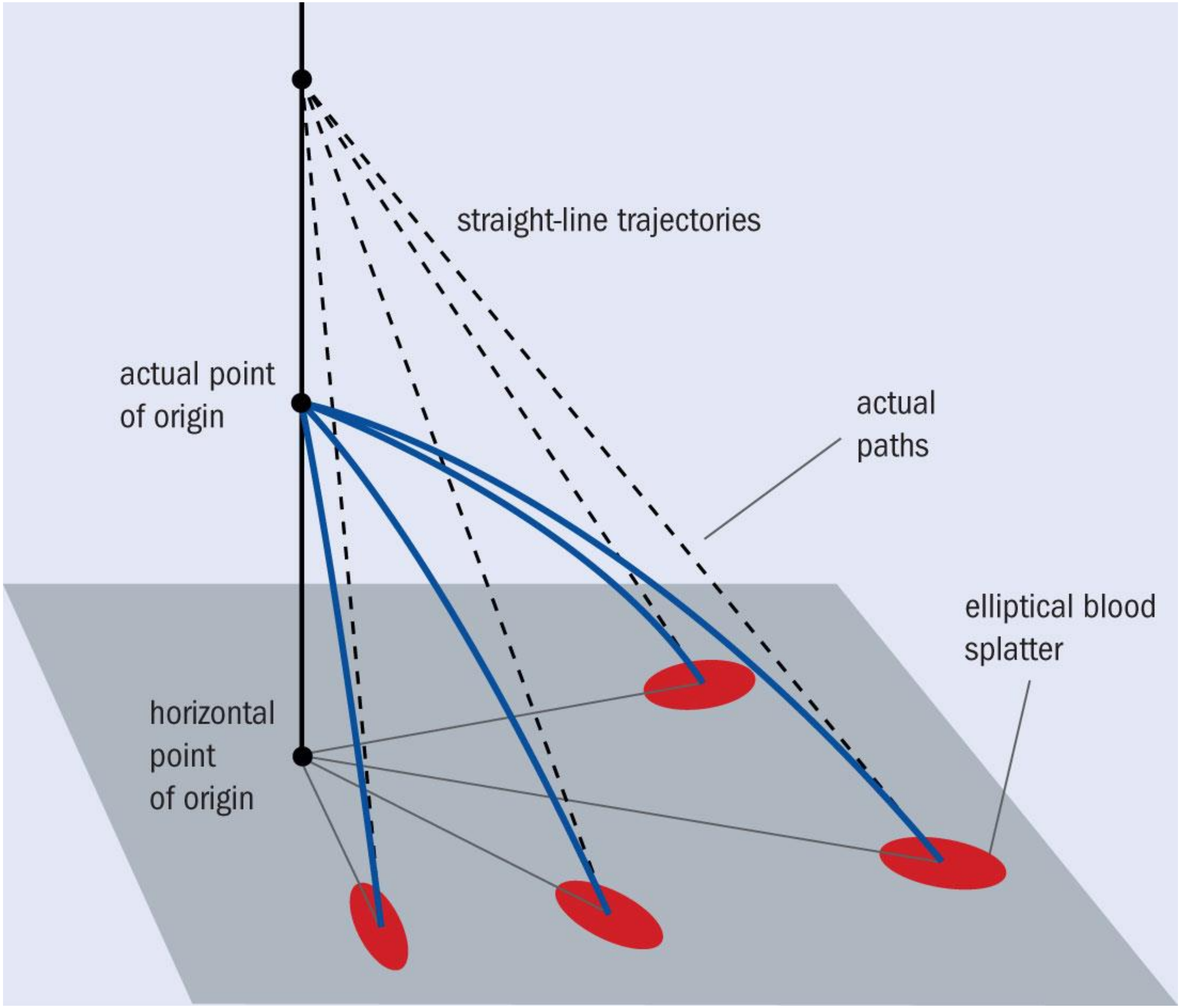
Smaller satellite or secondary droplets may break away from the main drop of blood. These satellites will appear **<u>IN FRONT</u>** of the moving droplet of blood.

Lines of Convergence

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 **MEET**, this will indicate the lines of convergence.

When there are numerous blood spatters, the area where the lines of convergence meet is where the source of blood **ORIGINATED**.

- A small **CIRCLE** is then drawn around this intersecting area to note the area of convergence.


straight-line trajectories
actual point
of origin
actual
paths
elliptical blood
splatter
horizontal
point
of origin

POINT OF ORIGIN

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 the 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 (line so 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.

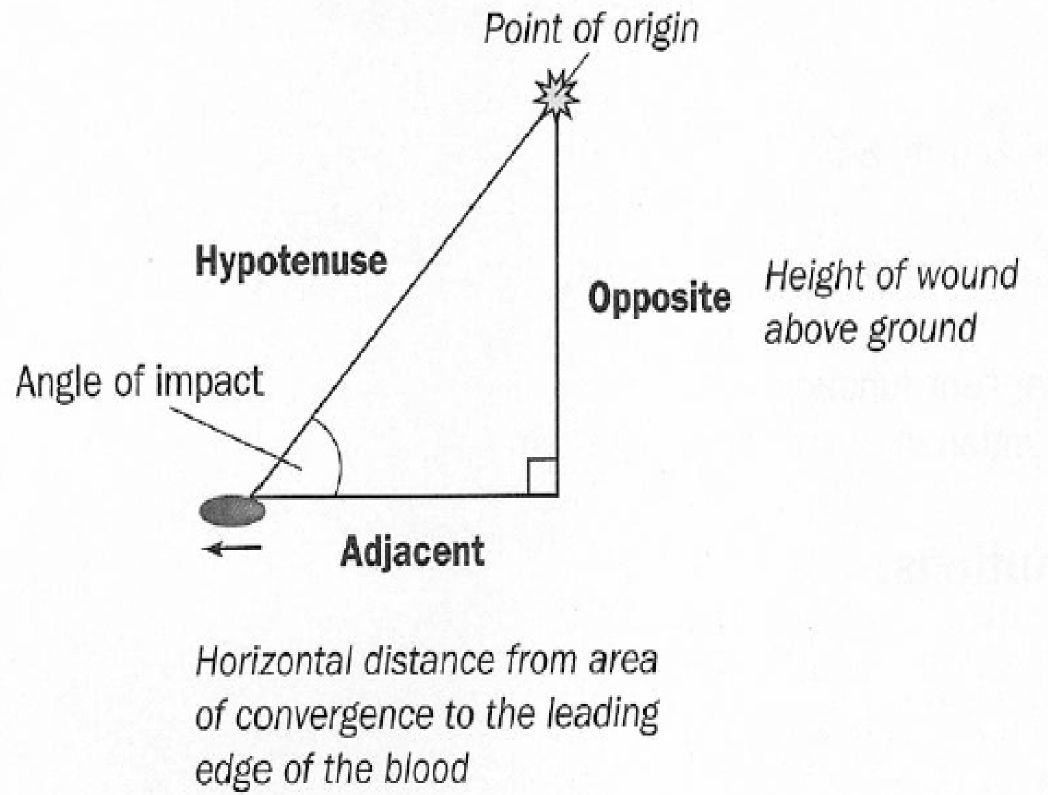
By measuring the width and length of a single drop of blood, you can determine the angle of impact.

By using the Law of Tangents, you can calculate the height from which the blood fell, or the point of origin for the blood.

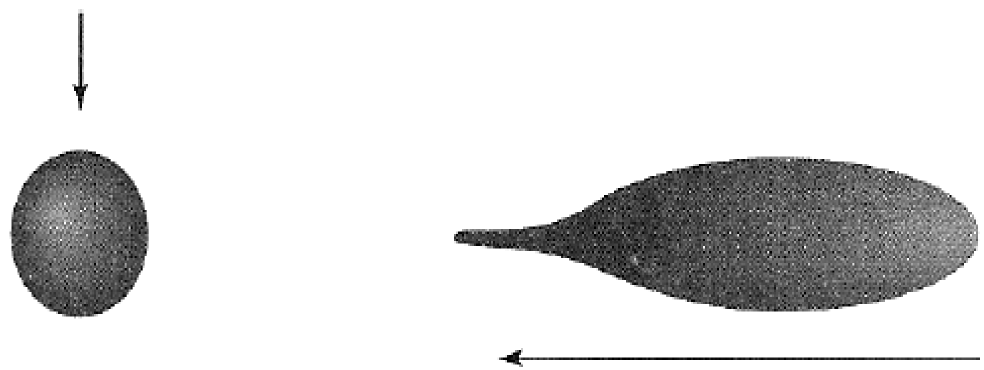
Math Review:

Right triangle

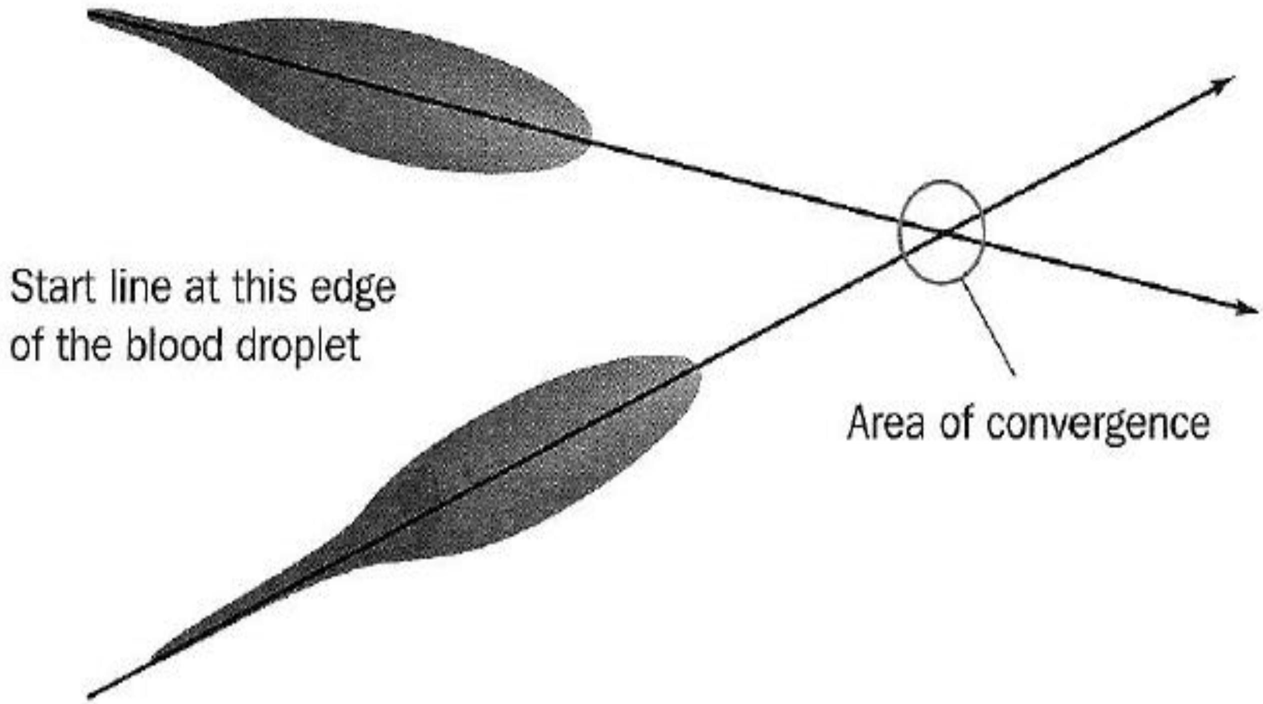
- Contains one 90° angle
- The hypotenuse is the longest side of a triangle, opposite the 90° angle (right angle)
- The opposite side to an angle is the side directly opposite the angle of interest
- The adjacent side to an angle if the side closest to the angle that is not the hypotenuse



1. Determine the direction of blood flow in the drops that follow with an arrow next to the droplet.
    a. If the blood drop is circular, then the blood fell at a 90° angle.
    b. If it is not circular, then the angle of impact was less than 90°.
    c. The elongated end of a drop of blood points to the direction in which the blood was moving.

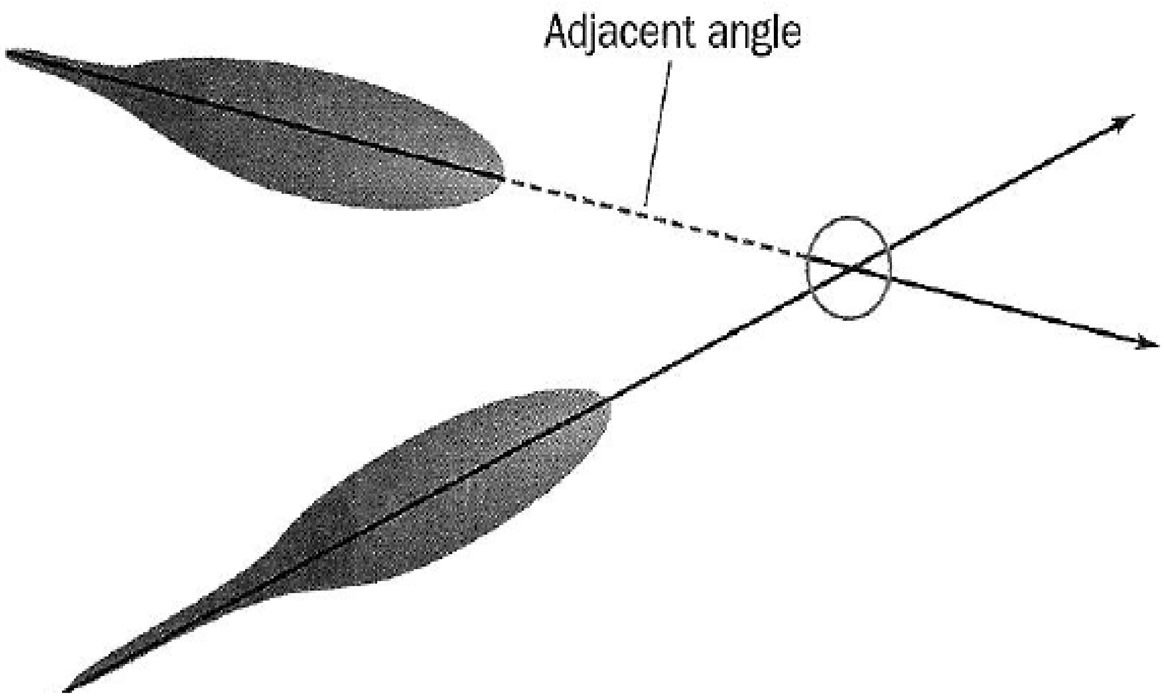


2. From several drops of blood, determine the area of convergence by drawing lines through each of the blood droplets and noting where the lines intersect.



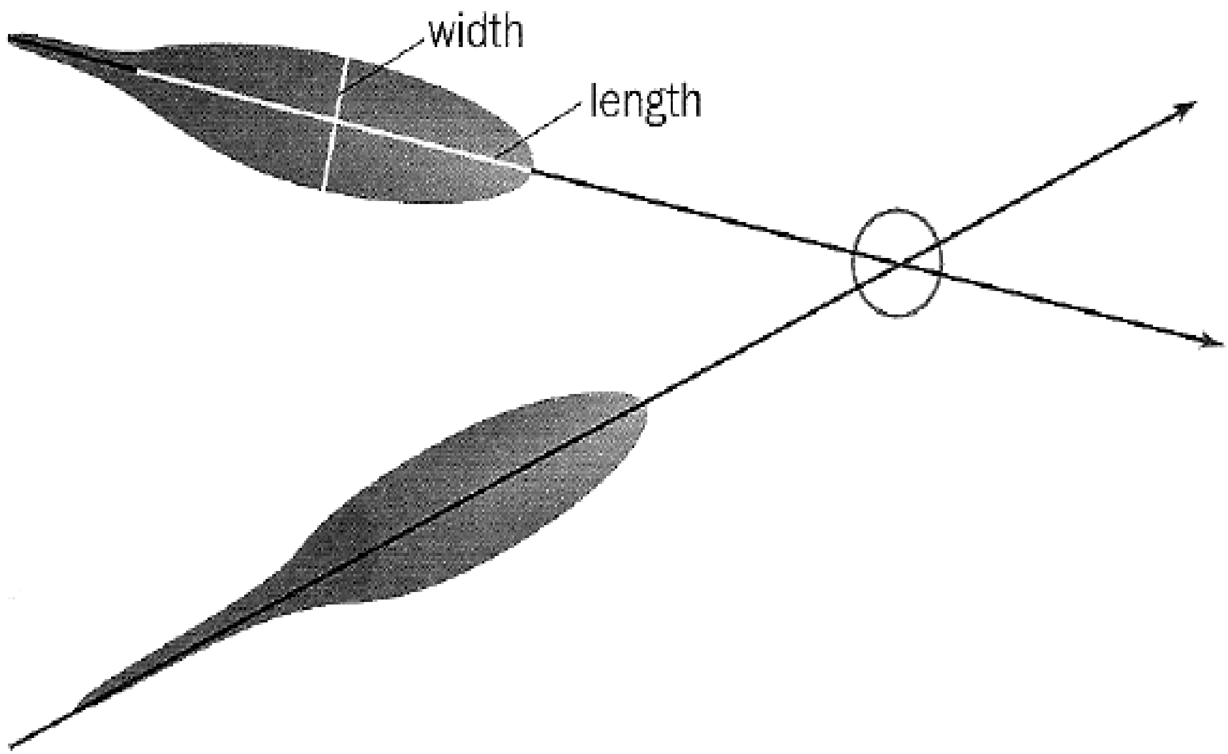
3. Once you have determined the area of convergence, you will measure the distance from the area of convergence to the edge of the drop of blood when it first impacted a surface. The distance is indicated by the dotted line.

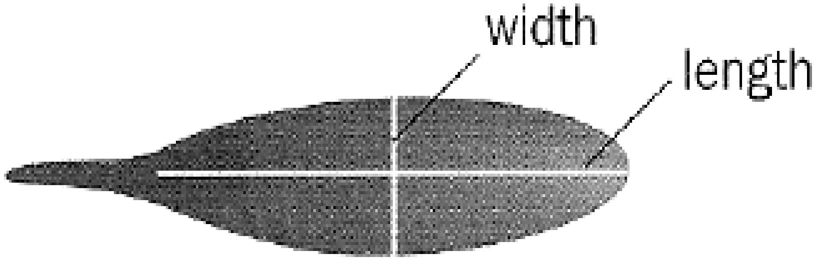
Recall the diagram of a right triangle. The dotted line represents the adjacent side of the angle of impact.



4. Next determine the angle of impact for each droplet of blood.
    a. Select one of the blood droplets and determine the angle of impact for that drop of blood.
    b. To calculate the angle of impact, you will need to use the Law of Sines.
    c. Remember, when you measure the length of the blood droplet, do not include the thin extension of the leading edge (tail).

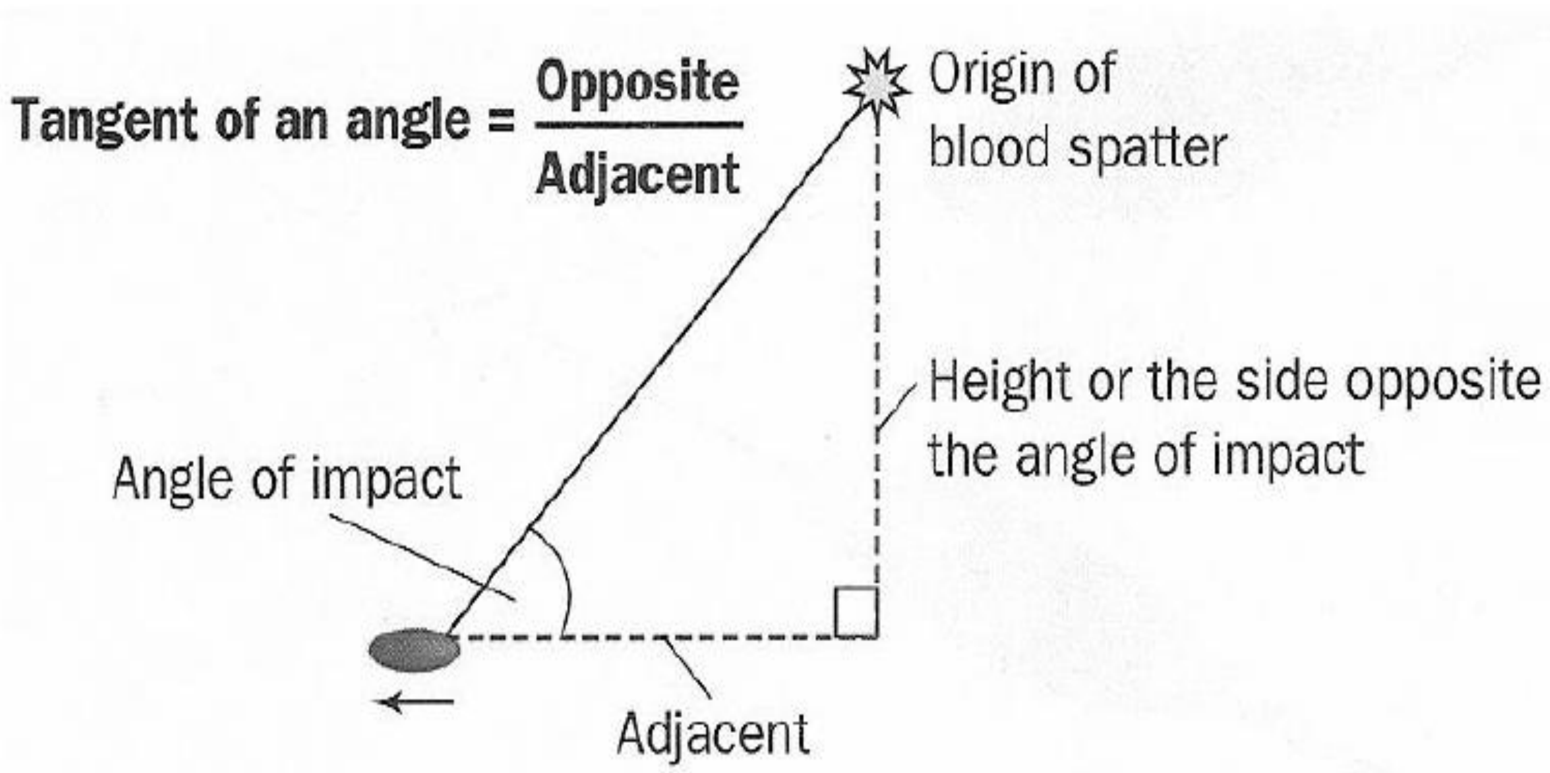
Sin of the angle of impact = width of the blood / length of the blood drop

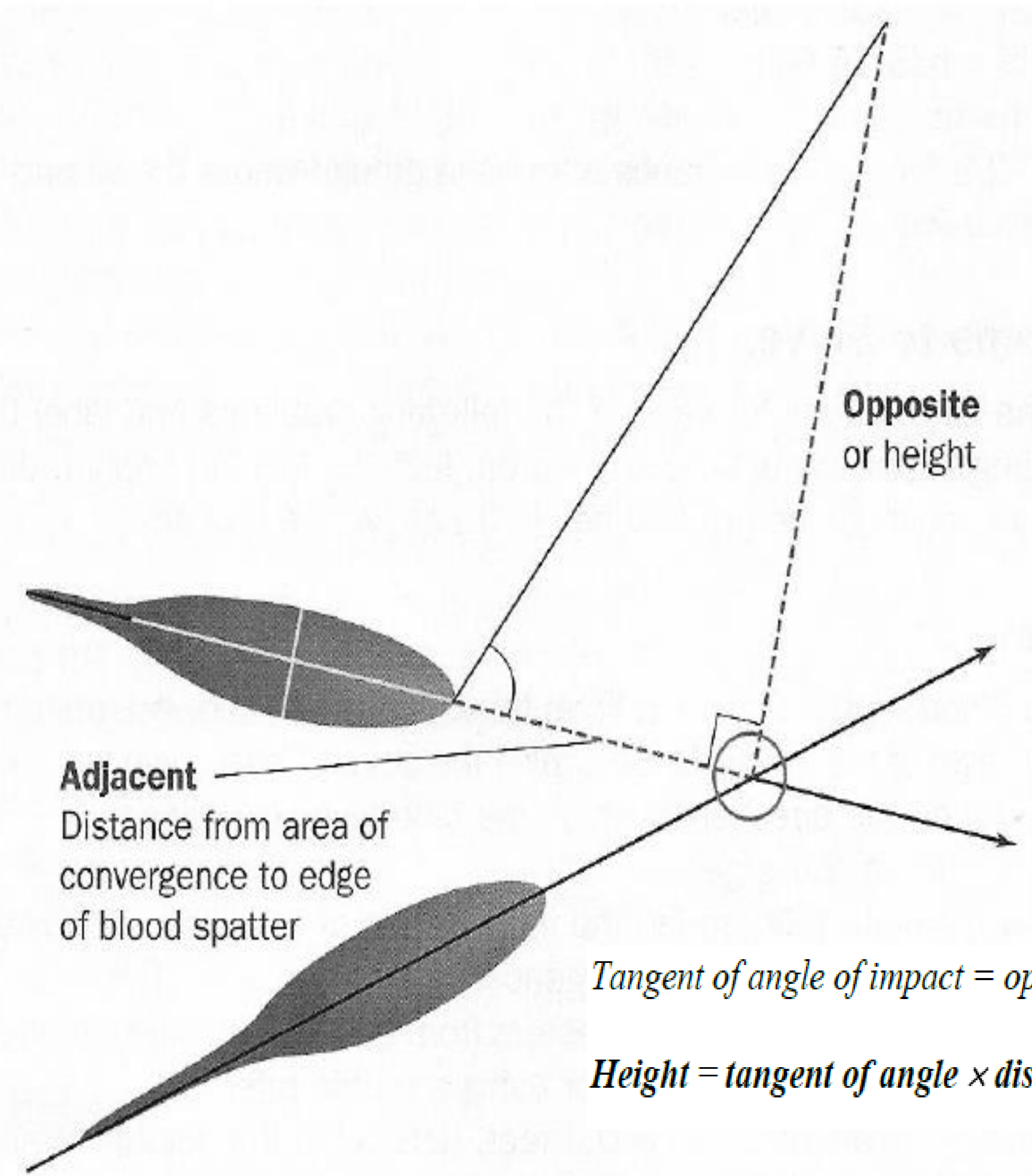




Sin of the angle = width / length = 14/45 = 0.3111
Sin of angle = 0.3111
Determine the inverse sine -----2nd sin (0.3111)
Impact angle = 18^{o}

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

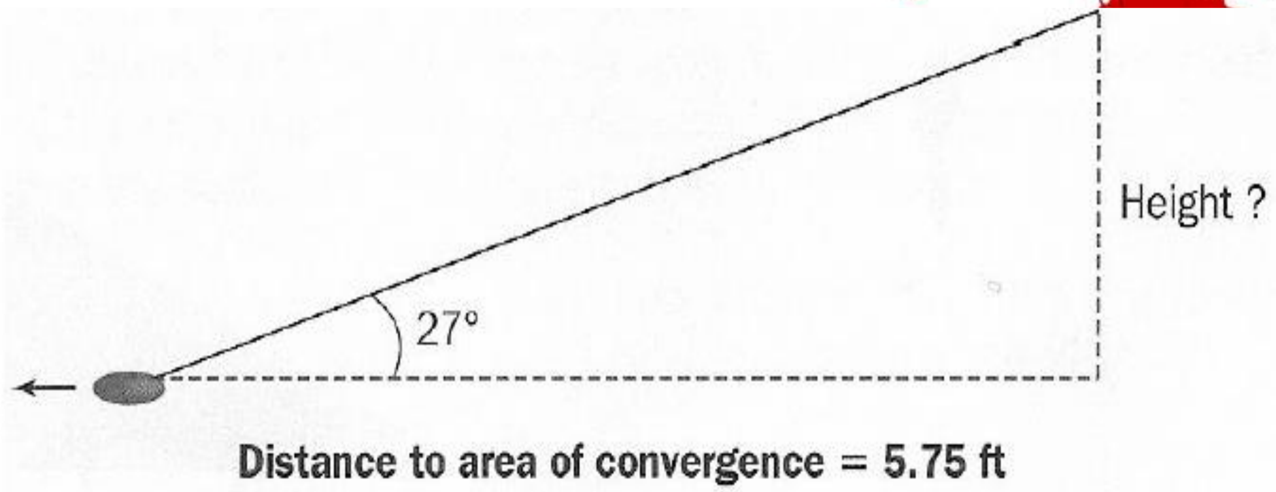




Tangent of angle of impact = opposite / adjacent = height / distance

Height = tangent of angle × distance

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

or

Tangent of blood-spatter angle = height of wound / distance from blood to area of convergence

$\tan 27^{\circ}$ = height if wound / distance

$\tan 27^{\circ}$ = height / 5.75 ft

Solving for height:

height = $\tan 27^{\circ} \times 5.75$ ft

height = 2.9 ft