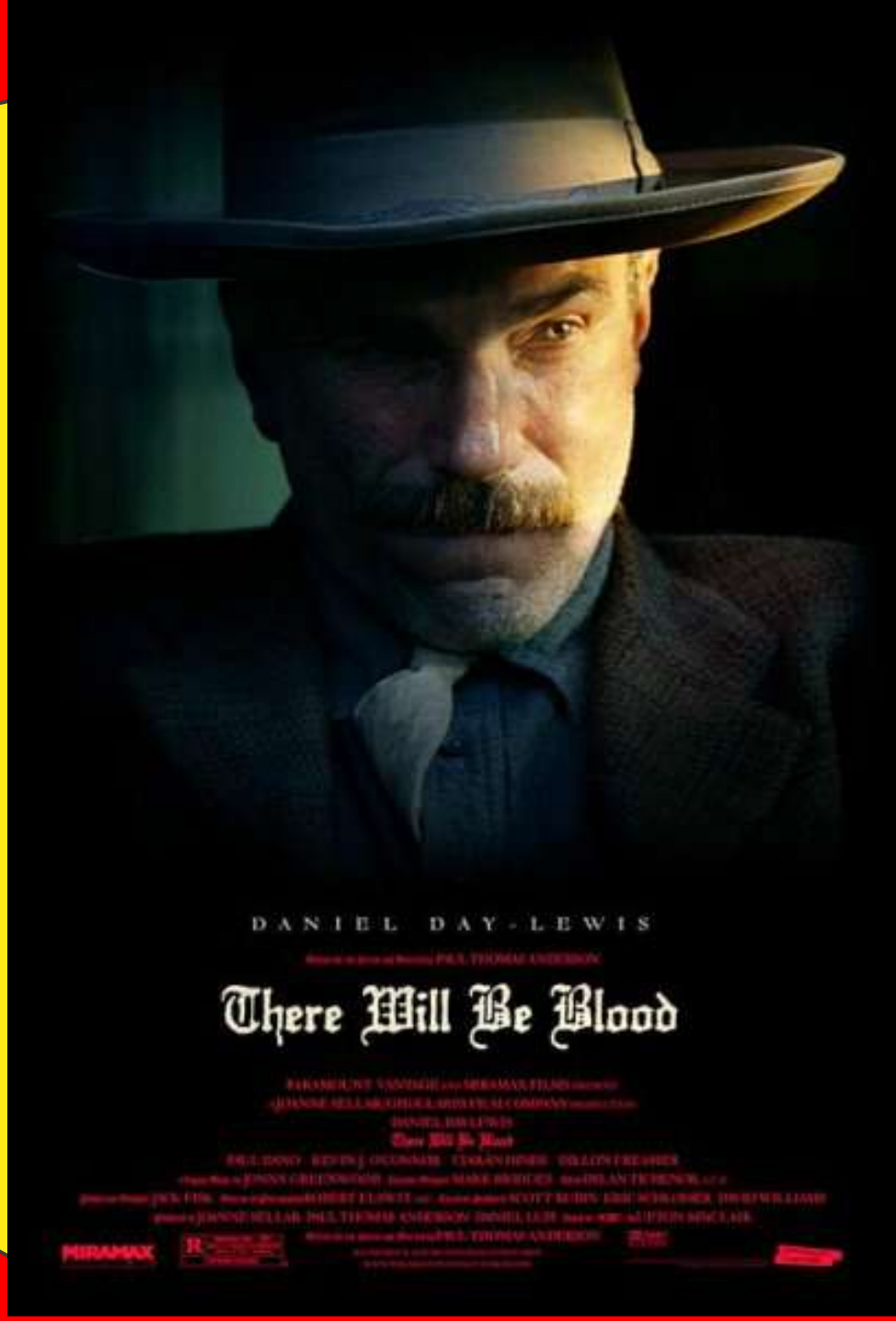
UNIT 5 – Applying Physics to Criminal Investigations "What, Physics in Mr. Stowers' Class?"

Standard 5.1

How fluid dynamics (blood spatter) are used to reconstruct a crime scene.

When you signed up for Mr. Stowers' class you knew…

Chapter 10



Chapter 10

What does the abbreviation BPA represent?

http://www.crimescenetwo.com/img/popup/book2p2.jpg

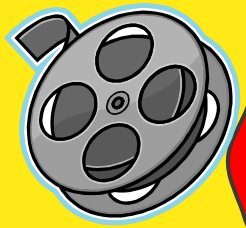
How is blood evidence detected at a crime scene?

Light Source

Investigators will first examine the crime scene to look for areas that may contain blood. They may use a high-intensity light or UV lights to help them find traces of blood as well as other bodily fluids that are not visible under normal lighting conditions.

Blood Reagent Tests

These tests, referred to as **presumptive tests**, are used to detect blood at crime scenes based upon the properties of hemoglobin in the blood. Further tests at the crime lab can determine if it is human blood or not.



Kastle-Meyer Test Video

Examples:

• **Phenolphthalein** is a chemical that is still utilized today and is usually referred to as the Kastle-Meyer test and produces a pink color when it reacts with hemoglobin.

•**HemaStix** is a strip that has been coated with tetramethylbenzidine (TMB) and will produce a green or blue-green color with the presence of hemoglobin.

Luminol

This chemical is used by crime scene investigators to locate traces of blood, even if it has been cleaned or removed.

Investigators spray a luminol solution is throughout the area under investigation and look for reactions with the iron present in blood, which causes a **blue luminescence**.

One problem is that other substances also react, such as some metals, paints, cleaning products, and plant materials. Another problem is that the chemical reaction can destroy other evidence in the crime scene.

Luminol Reaction

Fluorescein

This chemical is also capable of detecting latent or old blood, similar to luminol. It is ideal for fine stains or smears found throughout a crime scene. After the solution has been sprayed onto the substance or area suspected to contain blood, a UV light and goggles are used to detect any illuminated areas, which appear greenish-white if blood is present. It may also react to many of the same things as luminol (copper and bleach).

Fluorescein Reaction in UV Light

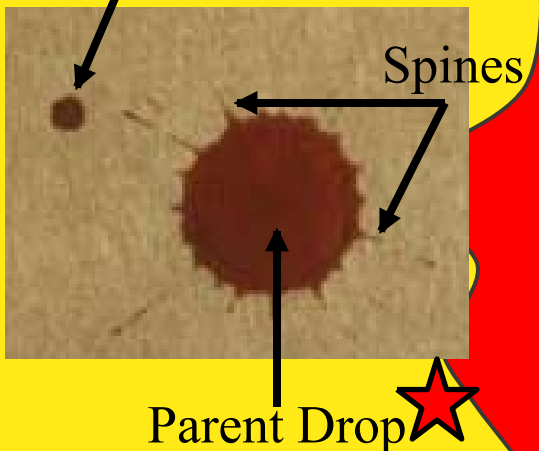
LCV or **Leuco Crystal Violet**, is one type of chemical process that is used for blood enhancement. Using this test helps to make the blood evidence more **visible** so it can be photographed and analyzed.

Bloodstain Pattern Analysis Terms

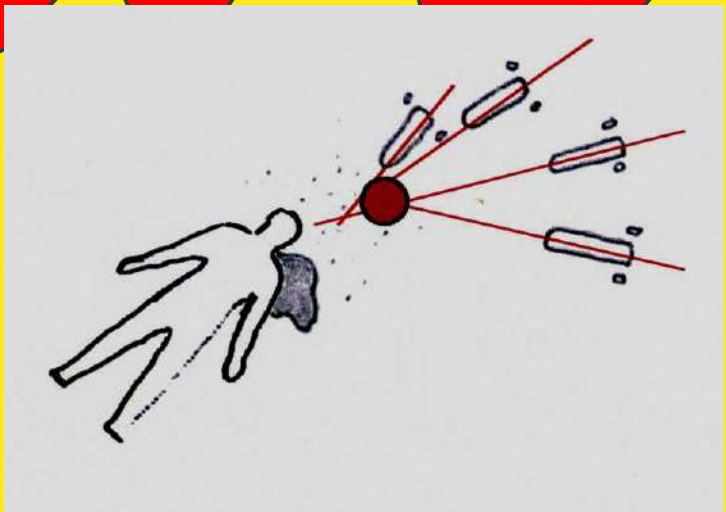
- **Spatter** – Bloodstains created from the application of force to the area where the blood originated.
- **Origin/Source** – The place from where the blood spatter came from or originated.

Angle of Impact – The angle at which a blood droplet strikes a surface.

- **Parent Drop** – The droplet from which a satellite spatter originates.
- **Satellite Spatters** – Small drops of blood that break off from the parent spatter when the blood droplet hits a surface.
- **Spines** – The pointed edges of a stain that radiate out from the spatter; can help determine the direction from which the blood traveled.



Blood Spatter



- In 1939 the meaning of the spatter pattern was first analyzed.
- When a wound is inflicted, a blood spatter pattern may be created.
- It takes a grouping of blood stains to make a blood spatter pattern.

Why is it important in forensics?

- Bloodstain patterns can be used to prove or refute a suspect's account of what happened.
- The information from the bloodstain patterns can possibly be used to reconstruct a crime.
- Bloodstain pattern analysis can tell us the "how" of a crime.

What can an investigator learn from the analysis of a blood spatter?

- Type and velocity of weapon
- Number of blows
- Handedness of assailant (right or left-handed)
- Position and movements of the victim and assailant during and after the attack
- Which wounds were inflicted first
- Type of injuries
- How long ago the crime was committed
- Whether death was immediate or delayed

Source: http://science.howstuffworks.com/bloodstain-pattern-analysis1.htm

Blood

- Blood is a fluid that makes up approximately 8% of the weight of a human body.
- Females have approximately 4-5 liters while males have between 5-6 liters.

Properties of blood

- **Blood has certain properties that can be compared to water.**

	Water	Blood
Viscosity	1.0 $mP \cdot s^{-1}$	3-4 $mP \cdot s^{-1}$
Surface tension	0.073 $N \cdot m^{-1}$	0.058 $N \cdot m^{-1}$
Density	1000 kg/m^3	1060 kg/m^3

Surface tension

- **Surface tension is an upwards force that enables insects such as a water strider to “walk on water”.**

Image: Water strider: David Cappaert, www.insectimages.org

Surface tension

- **Surface tension enables blood droplets to maintain a sphere shape.**

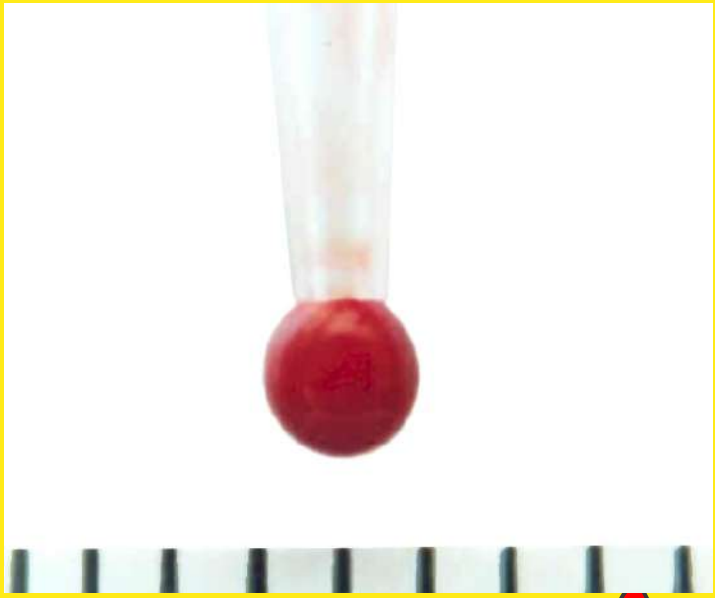
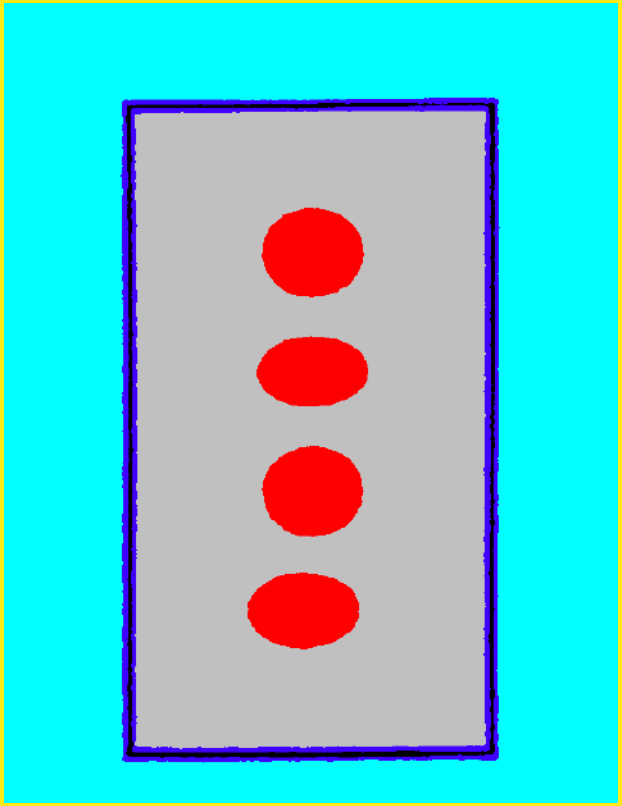


Image courtesy UWA PhD research student Mark Reynolds.

Traveling blood droplets

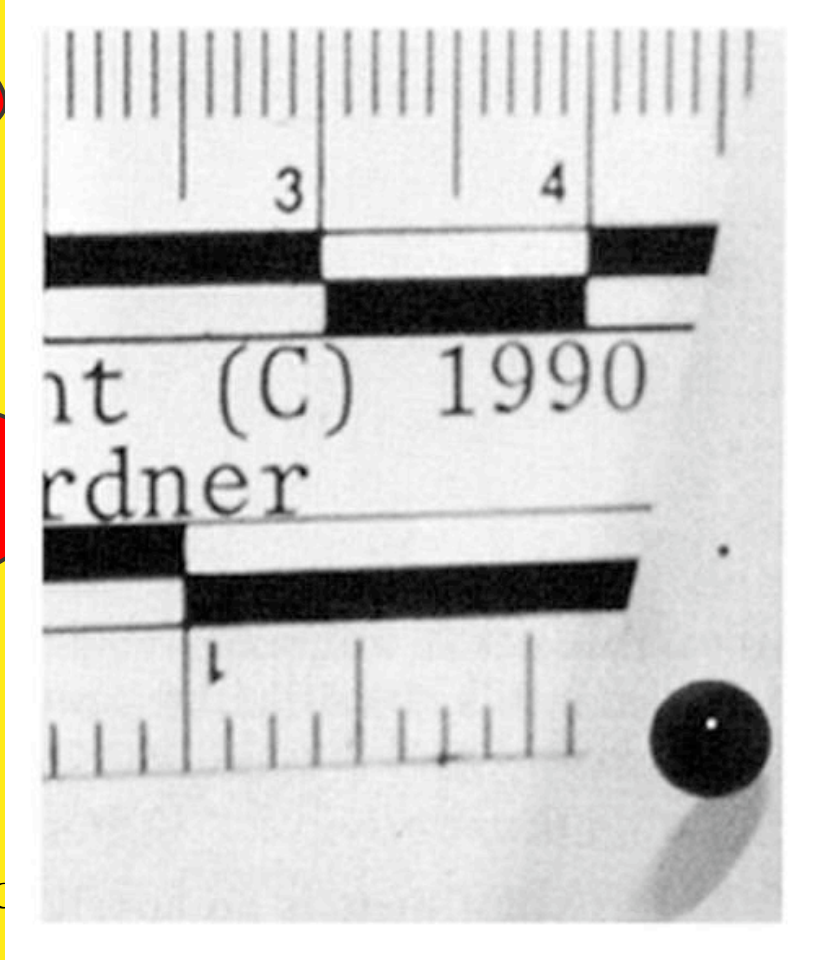
- When a force is applied to a mass of blood, the blood breaks into droplets.
- The droplets fly through the air as "perfect" spheres due to surface tension.
- Note that this is unlike the classic tear-drop shape often seen!



- **The blood drop will oscillate as it falls due to air resistance.**

Stages of impact

Stage 1: contact & collapse



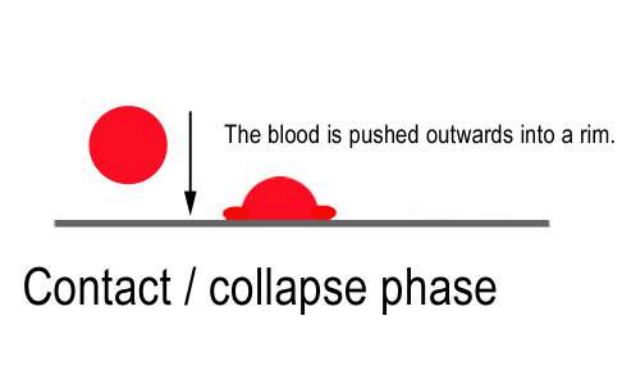
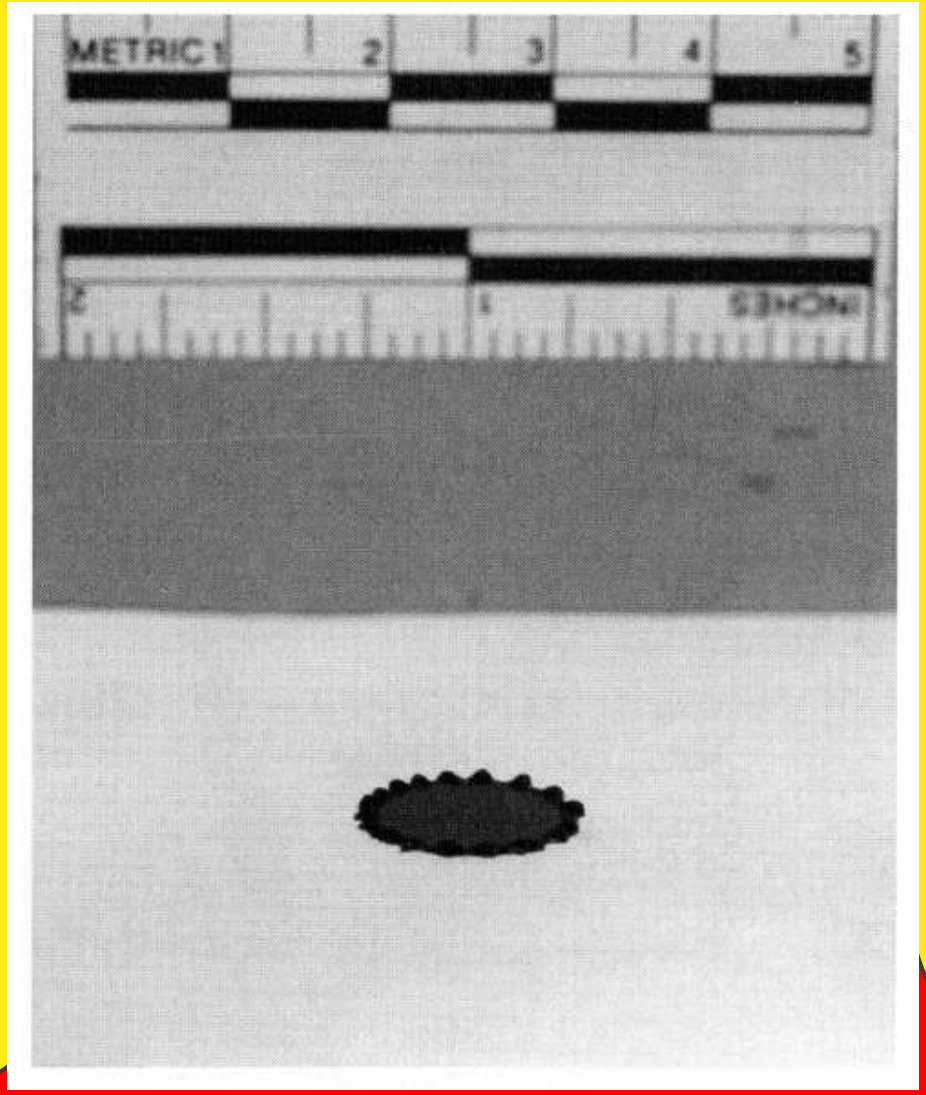


Image used with permission from Tom Bevel & Ross Gardner, June 2006.

Stage 2: displacement



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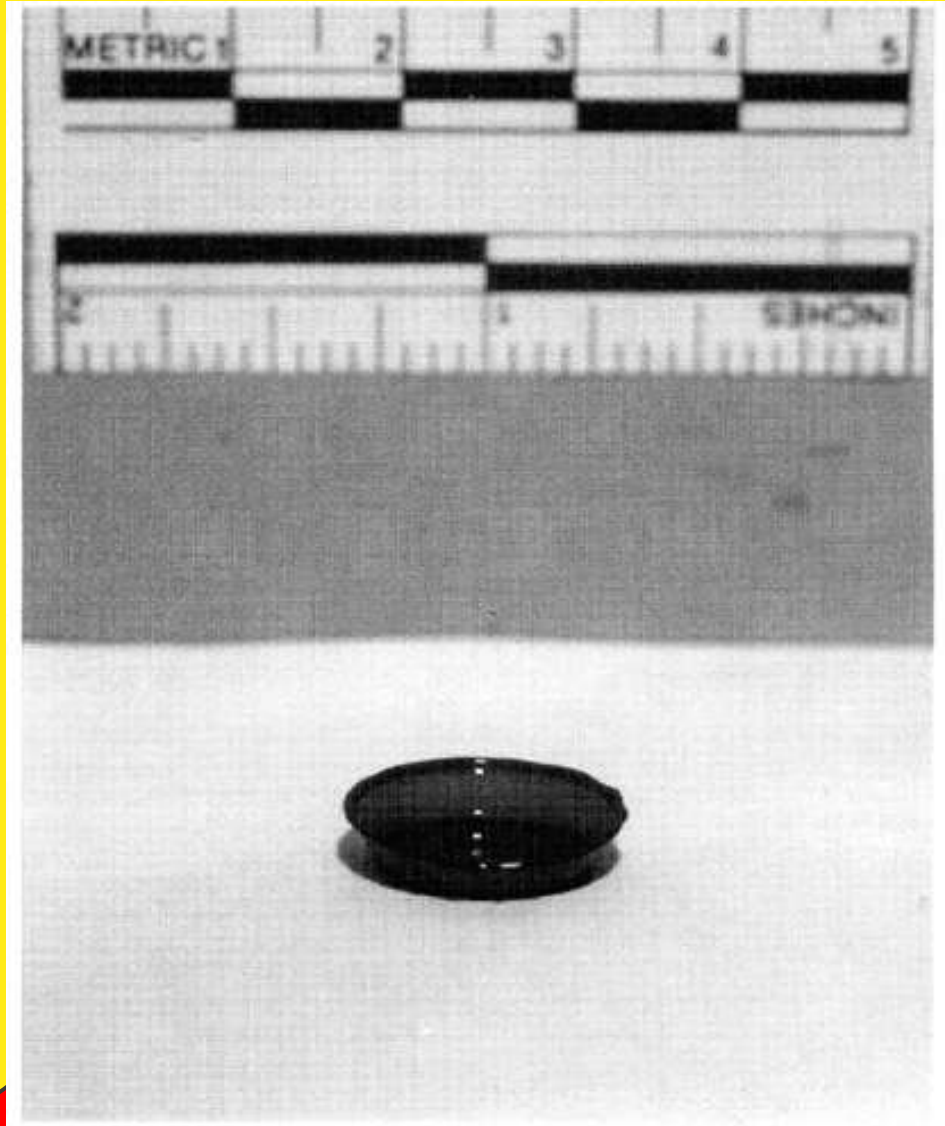
Stage 3: dispersion



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Stage 4: retraction

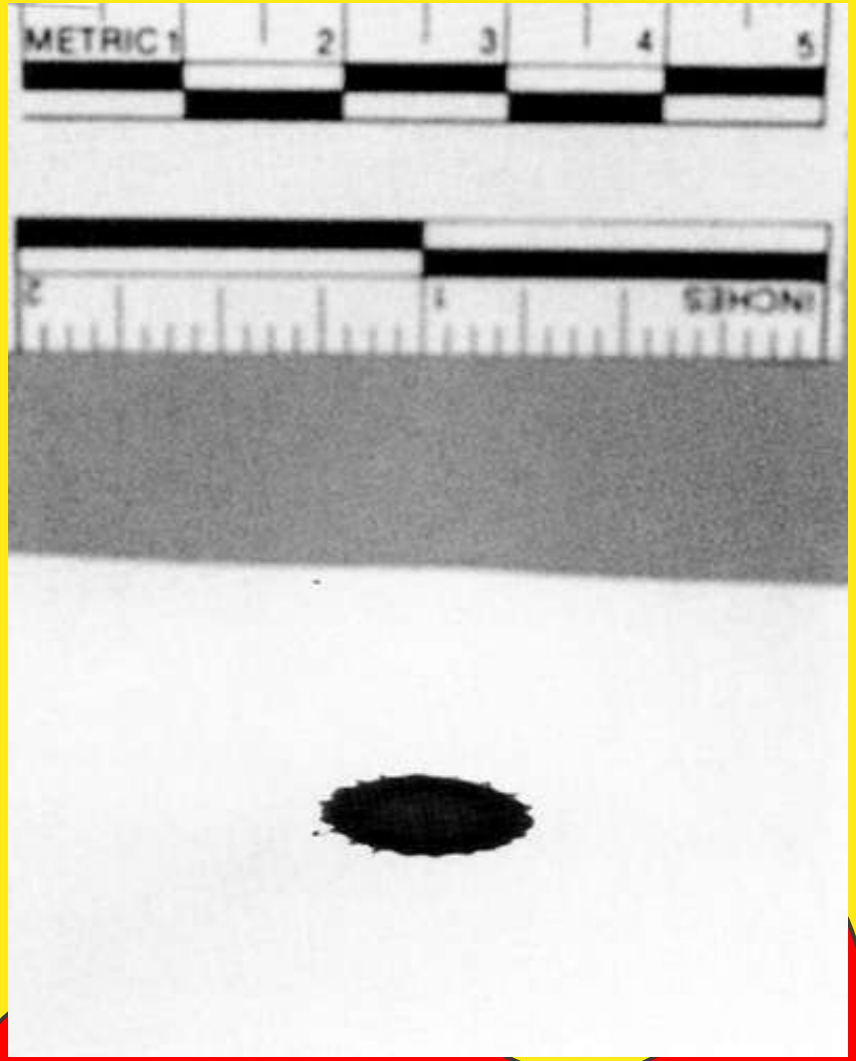
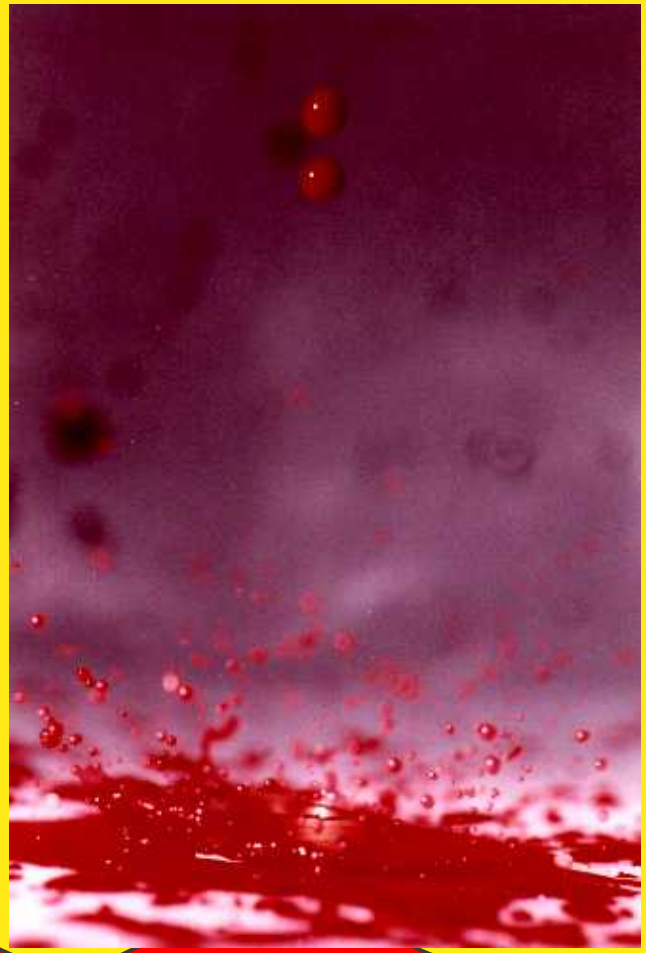
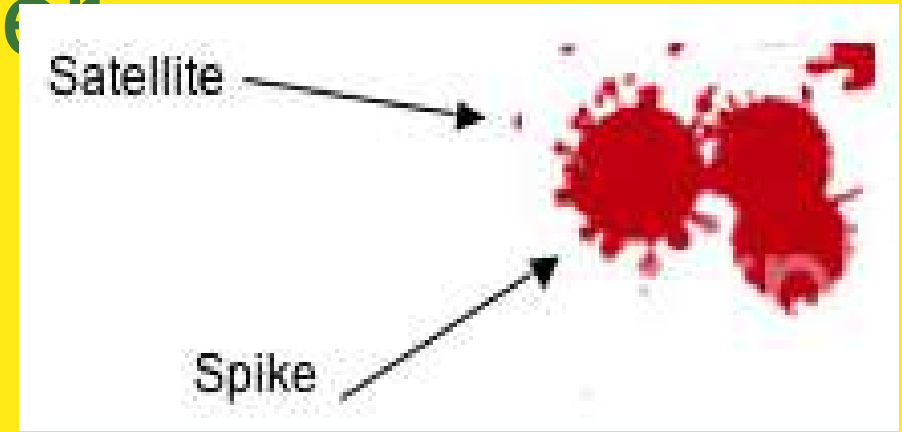


Image used with permission from Tom Bevel & Ross Gardner, June 2006.

- **Corona effect:** blood falling into a pre-existing pool of blood. The pattern radiates out from the point of impact. (When stopped via flash photography, the radiating droplets look like a crown, hence the term “corona”.)

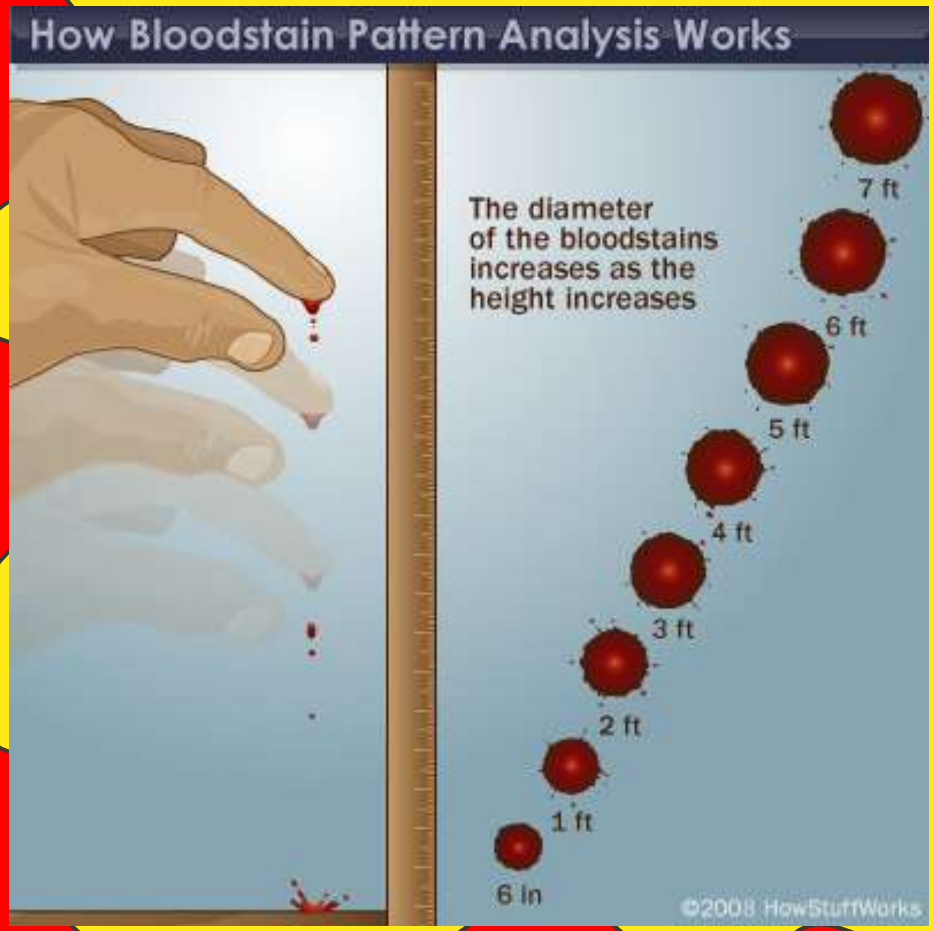


Blood Spatter Analysis



- When blood falls from a height or at a high velocity, it can overcome its natural cohesiveness and form **satellite droplets**.
- When it falls onto a less-than-smooth surface, it can form **spiking patterns** around the drops.

Height and size of blood drops



- **A blood droplet released from a 1m height will be smaller than a blood droplet released from a 1.5m height.**
- **This is because the velocity of the blood droplet released from a higher height is greater.**

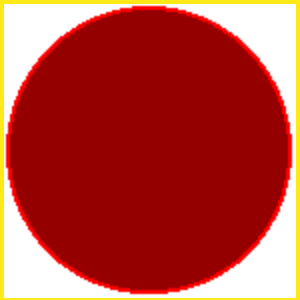
Surfaces and blood

- 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.

Ch

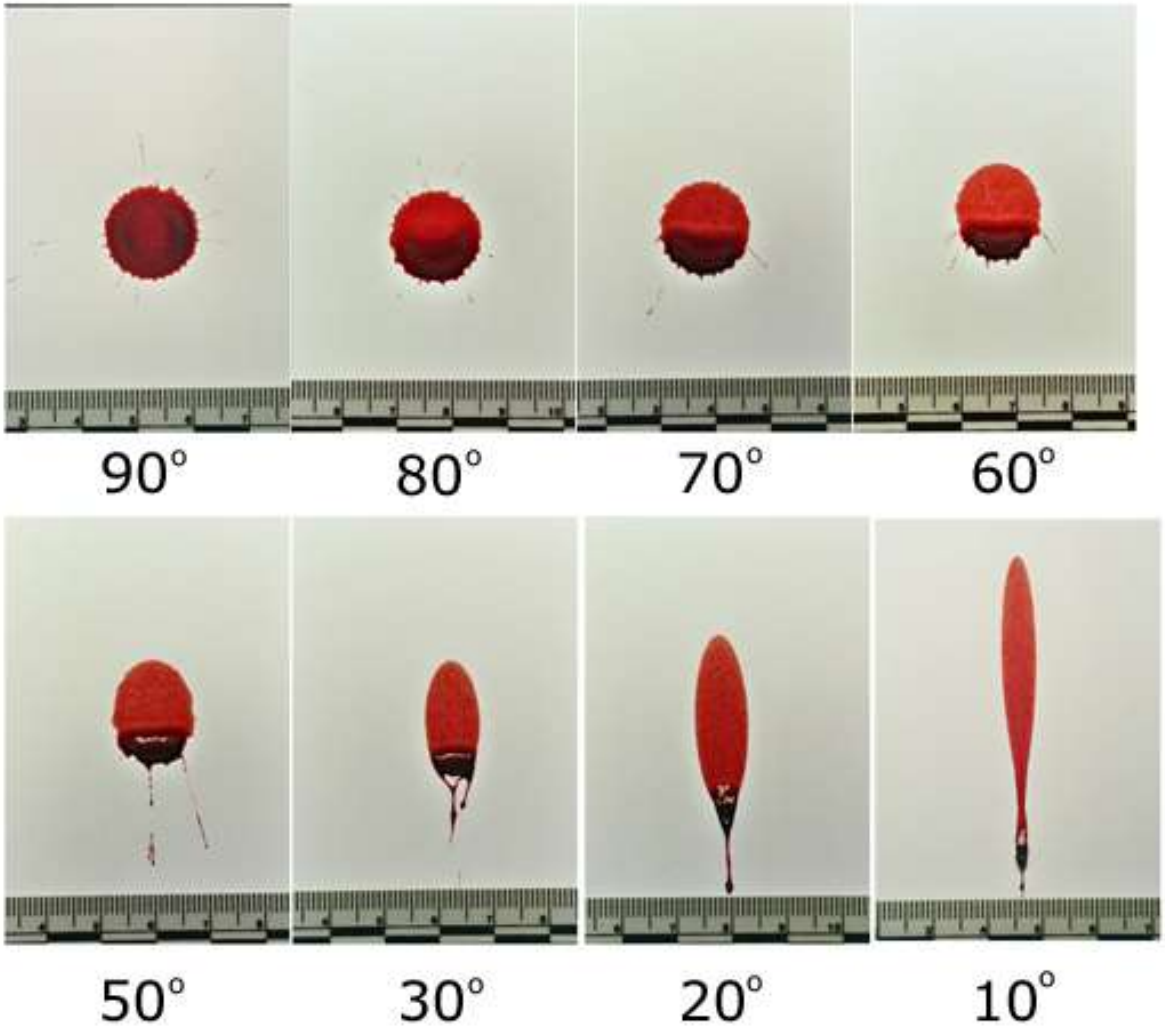
Surfaces and Blood

- Smooth Surface



- Textured Surface

Angle of impact

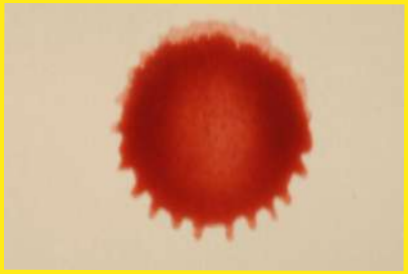


Decreasing angles of impact of single falling blood droplets.

Image used with permission from Stuart James, February 2007.

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.



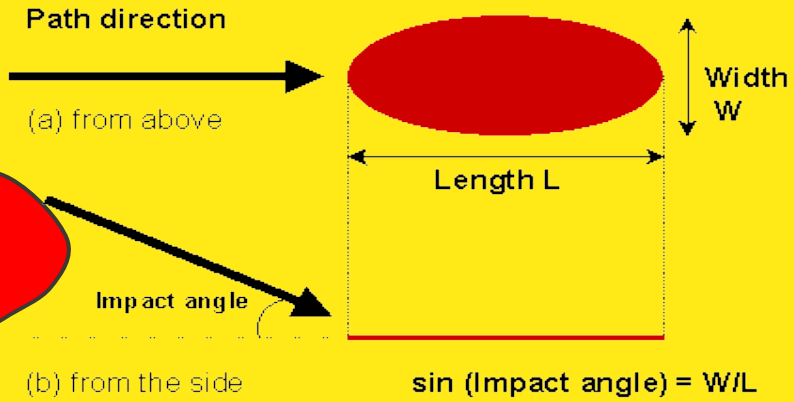
Bloodstain Patterns

The 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:

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

For example: In the blood droplet pictured the length is 1.7 cm and the width is 0.8 cm. What is the angle of impact?



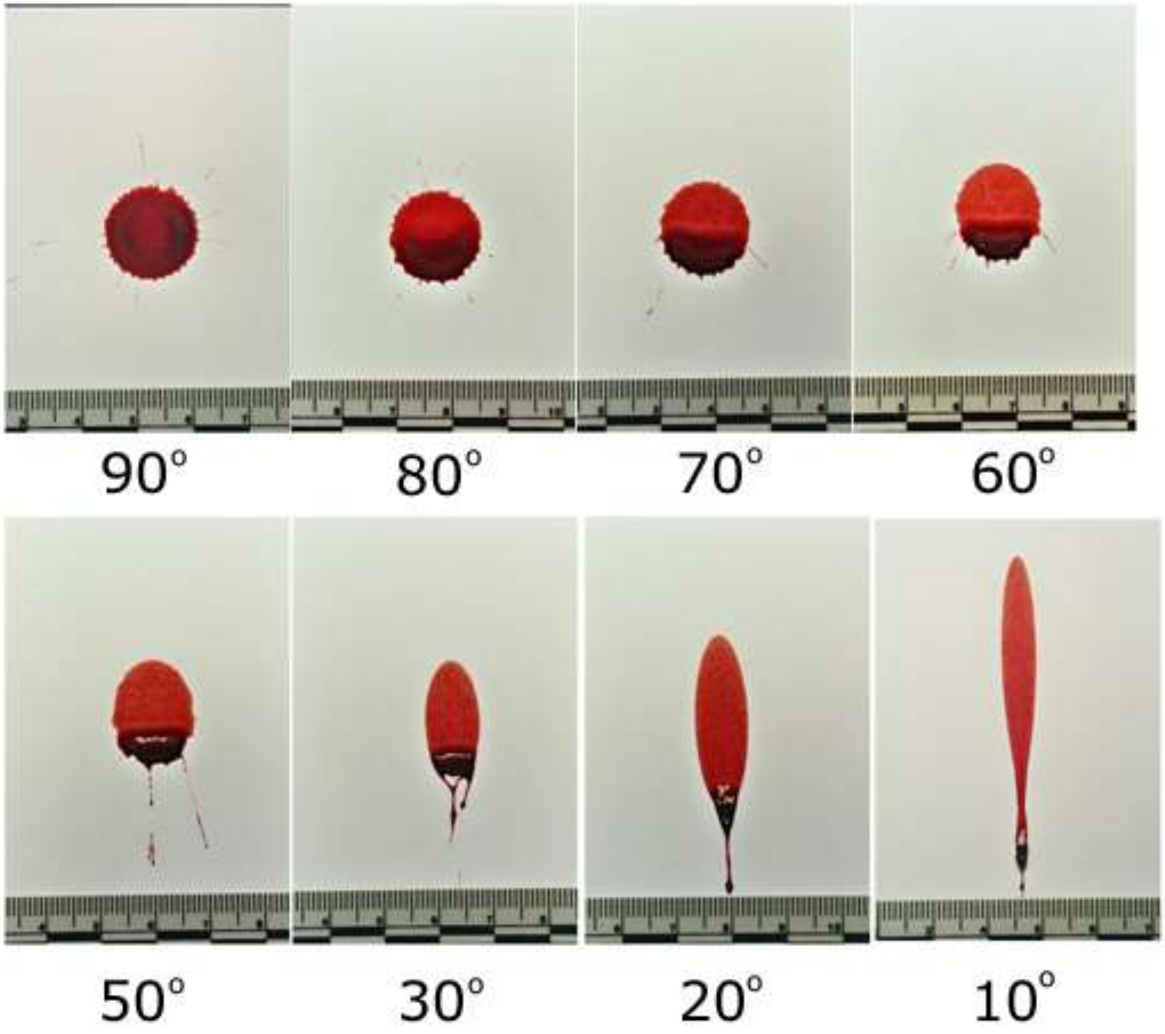
Sin-1(w/l) = impact angle

Sin-**1**(0.8/1.7) = impact angle

28° = impact angle

Sin^{-1}(width/length) = impact angle

Angle of impact



Decreasing angles of impact of single falling blood droplets.

Image used with permission from Stuart James, February 2007.

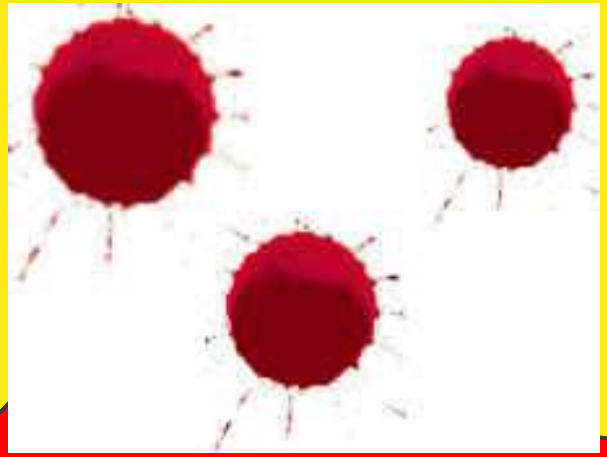
Types of Blood Stain Patterns

1. Passive
2. Projected
3. Transfer

1. Passive Bloodstains

Passive stains are drops created or formed by the force of gravity acting alone. They are low velocity stains.

This category can be further subdivided to include:



Drops
Drips
Pools

Passive: Dripped Blood

patterns created by a volume of blood, from same source to target distance (repeated drops onto same spot.)

Low Velocity Stain (LVS) characteristics

Usually associated with activities such as:

- **Drops falling passively to target**
- **Drip spatter (blood dripping into a pool of blood)**
- **Splashed blood**
- **Stepping into pool of blood**
- **Large volume of blood falling at least 4 inches**
- **LVS are usually large, due to low applied force. (> 3mm)**

2. Projected Bloodstains

- Projected blood spatter occurs when energy has been transferred to the blood source. The higher the velocity, the smaller the drops

- The size, shape, and number of resulting stains will depend, primarily, on the amount of force utilized to strike the blood source.

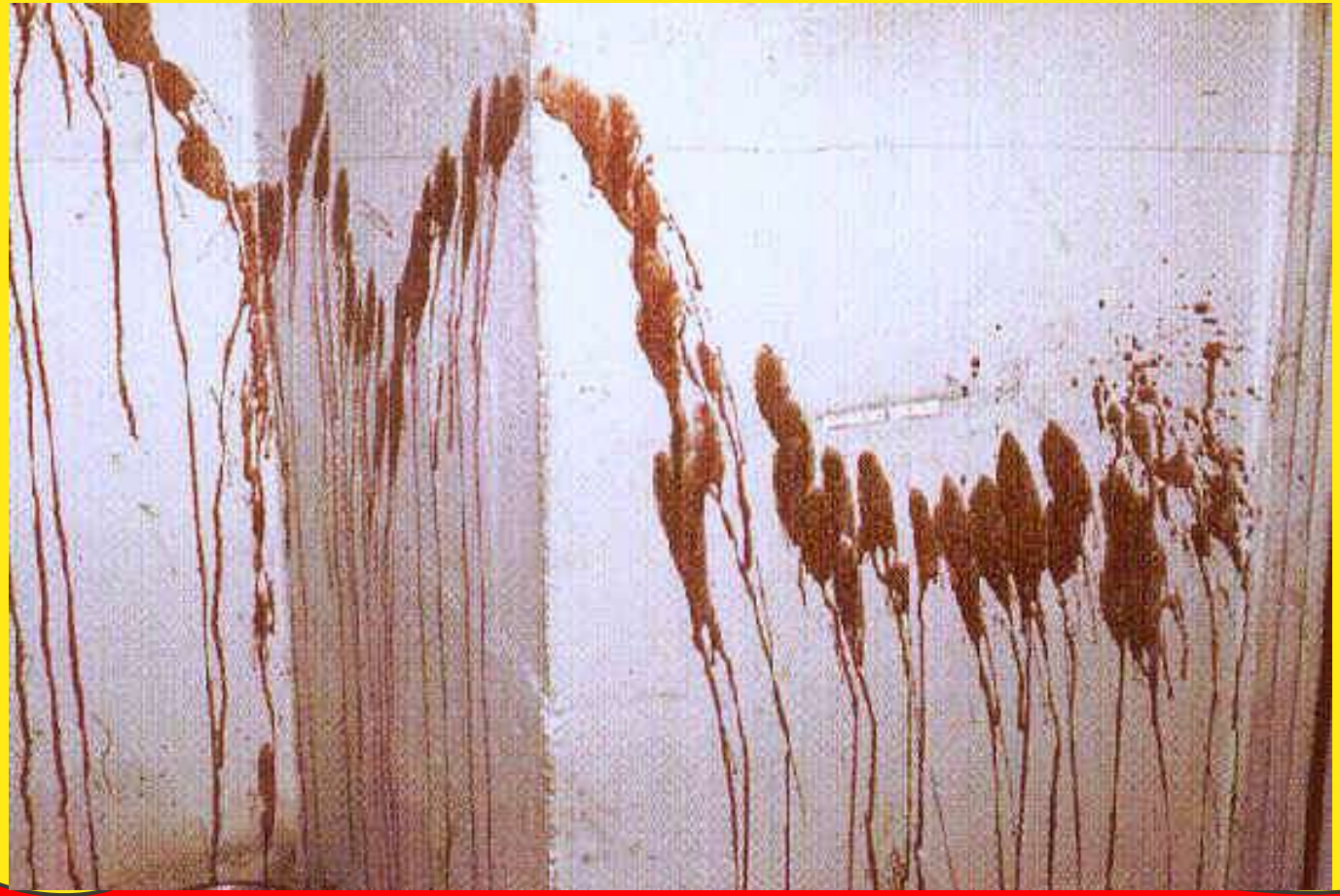
Types of Projected Blood Spatter

This category can be further subdivided to include:

- Low, Medium & High Velocity Impact Spatter
  - Falling blood drops
  - Gunshot wounds
- Cast-off stains
- Arterial Spurting
  - Cutting of an artery
- Expiratory
  - Blood from mouth or nose

Arterial gush or spurt

- Bloodstain pattern (s) resulting from blood exiting the body under pressure from a breached artery.



Projected blood through a syringe

Arterial spurt

Impact Spatter

- Blood stain patterns created when a blood source receives a blow or force resulting in the random dispersion of smaller drops of blood.

This category can be further subdivided into;

- Low Velocity
- Medium Velocity
- High Velocity

Low Velocity Impact Spatter

- **Gravitational pull up to 5 feet/sec.**
- **Relatively large stains 4mm in size and greater**

Low velocity

Low Velocity Impact Spatter

Medium Velocity Impact Spatter

- **Force of 5 to 25 feet/sec.**
- **Preponderant stain size 1 to 4mm in size**

Medium Velocity Stain Patterns

Usually associated with:

- Velocities of 5 – 25 fps
- Beatings or stabbings
- Most spatters are < 3mm in diameter

Medium velocity

High Velocity Stain Patterns

Usually associated with:

- **Velocities in excess of 100 fps**
- **Gun Shot Wounds**
- **Explosions**
- **Mechanical accidents involving high speed machinery**
- **Majority of spatters are < 1 mm (“mist”)**

HVS patterns – cont.

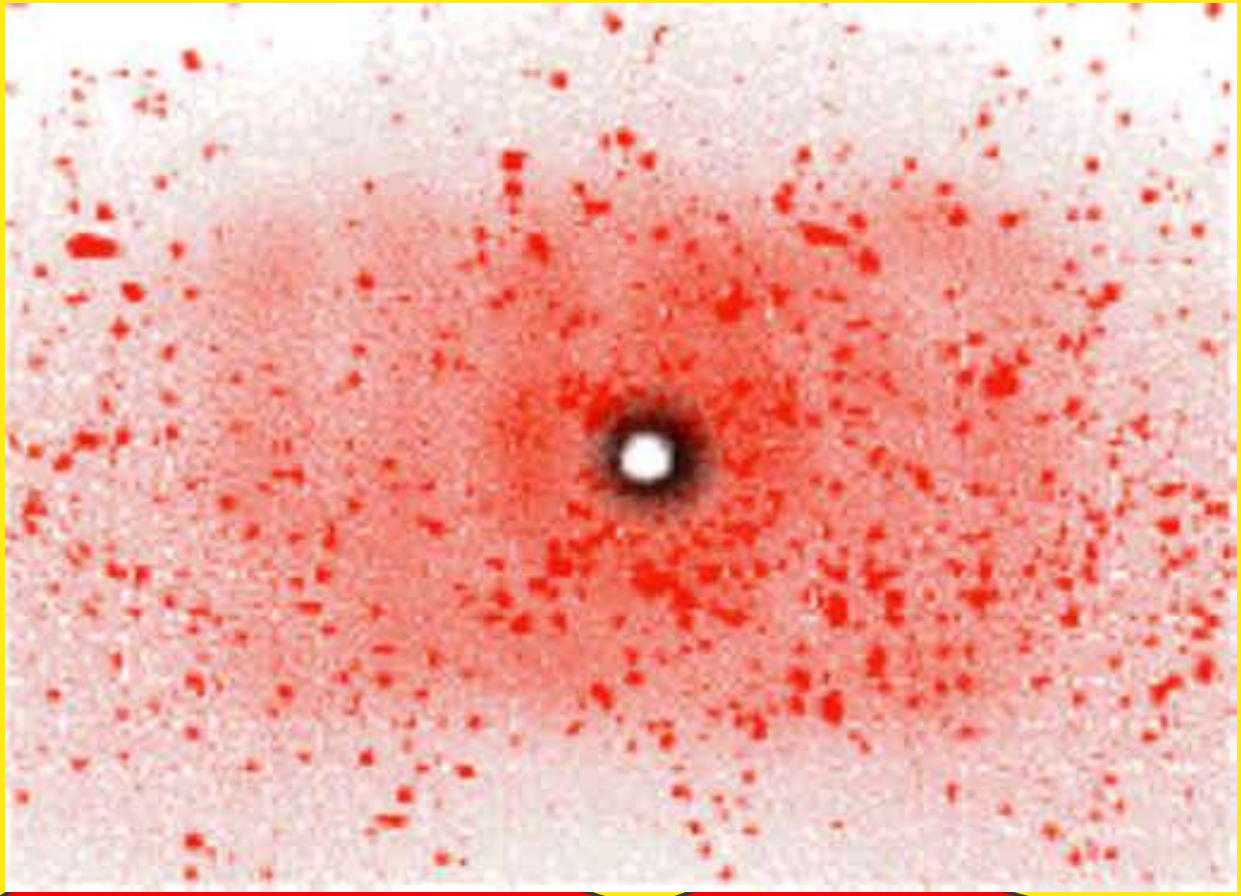
- Dry quickly
- Do not travel far
- If GSW – bullet entry angle determines spatter direction
- Often hidden (or missed) in textured surfaces, such as carpeting
- May exhibit both backspatter & forward spatter

High Velocity Impact Spatter

Force of 100 feet/sec. and greater

Preponderant stain size 1mm in size and smaller

Mist like appearance



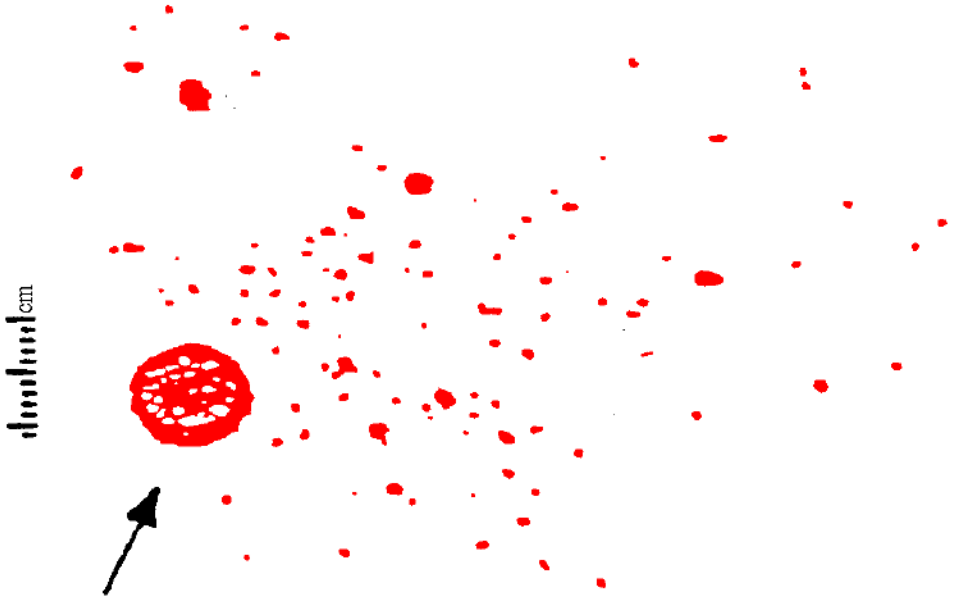
High velocity

Expiratory blood

- Expiratory blood can originated from two major locations – the nose & mouth, or from an open chest wound (commonly called a “sucking chest wound” in clinical settings.)
- If originating from the mouth, a degree of salivary dilution can occur, resulting in a blood stain that is noticeably lighter in appearance than one associated with normal blood.

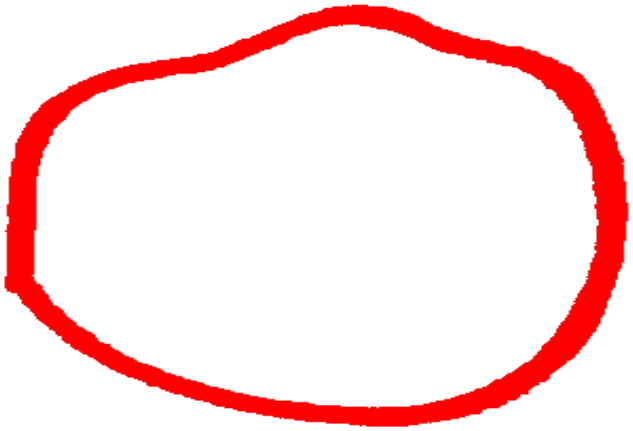
Expiratory Blood

The arrow points to a stain cause by a "bubble" of expired blood hitting the target surface.



Expiratory Blood

Skeletonized blood stain



Skeletonized stain

3. Transfer Bloodstains

- A transfer bloodstain is created when a wet, bloody surface comes in contact with a secondary surface.
- A recognizable image of all or a portion of the original surface may be observed in the pattern, as in the case of a bloody hand or footwear.

Types of Blood Spatter

- **Contact** or **Transfer** blood spatter occurs when an object with blood on it comes into contact with other objects.
  - A **wipe** pattern is created from an object moving through a bloodstain, while a **swipe** pattern is created from an object leaving a bloodstain

transfer

transfer

Chapter 10

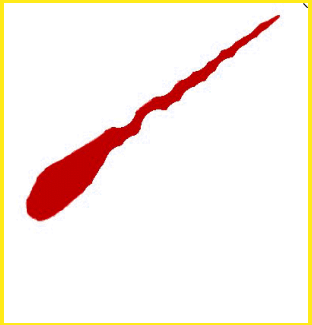
Chapter 10

Interpreting Blood Spatter

How to tell the direction that blood droplet was moving.

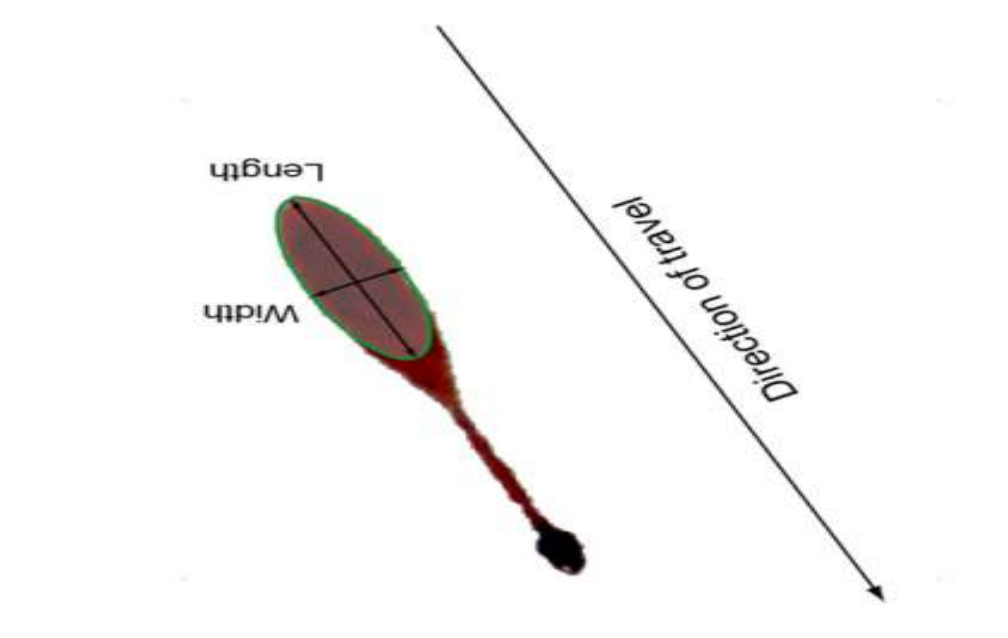
Here is a picture of some blood spatter which hit a surface

Direction towards "fat end"



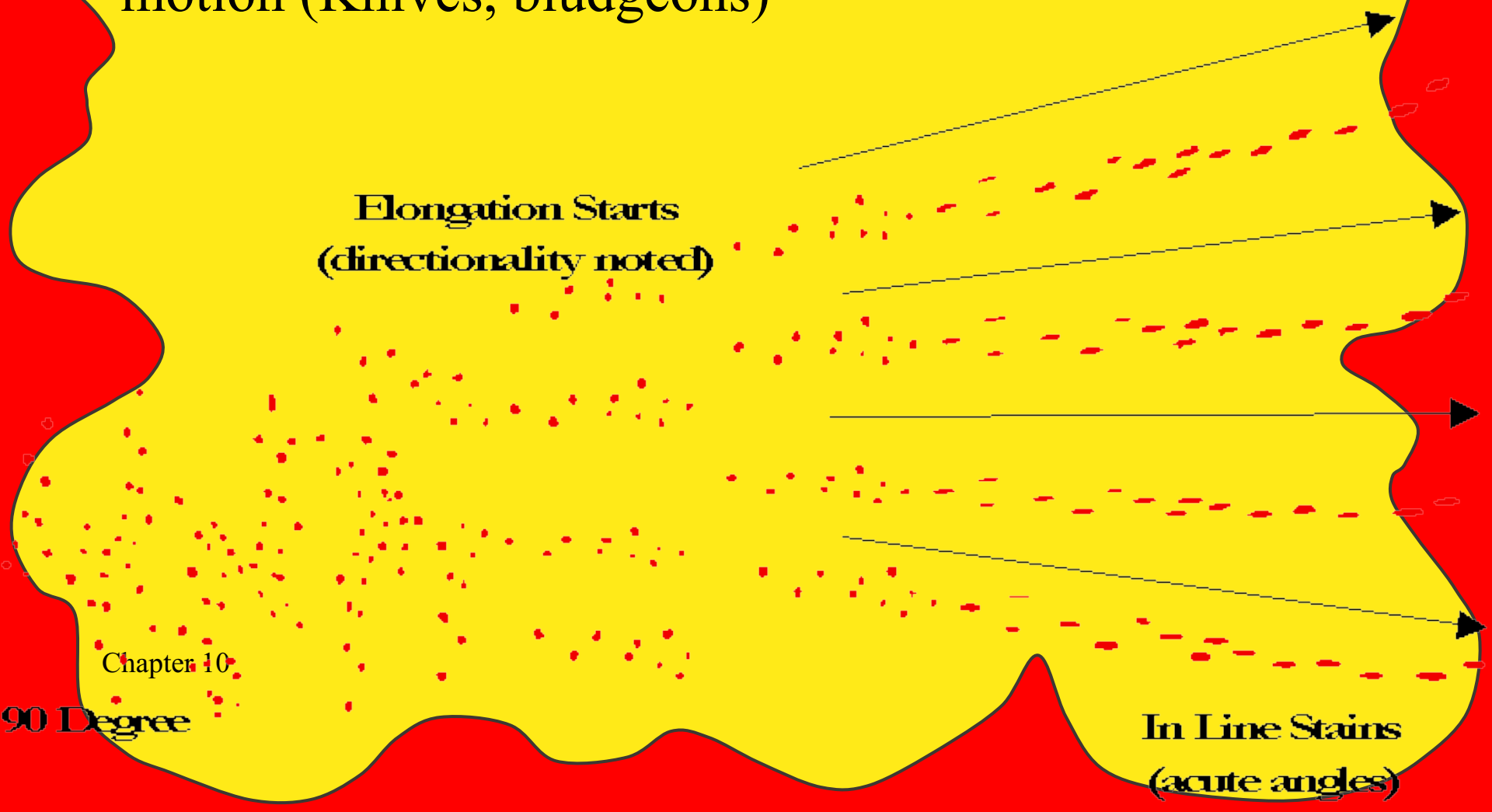
The pointed part of the blood spatter give you the direction the blood was traveling at the point of impact.

Interpreting Blood Spatter



Cast-off Stains

- Blood released or thrown from a blood-bearing object in motion (Knives, bludgeons)



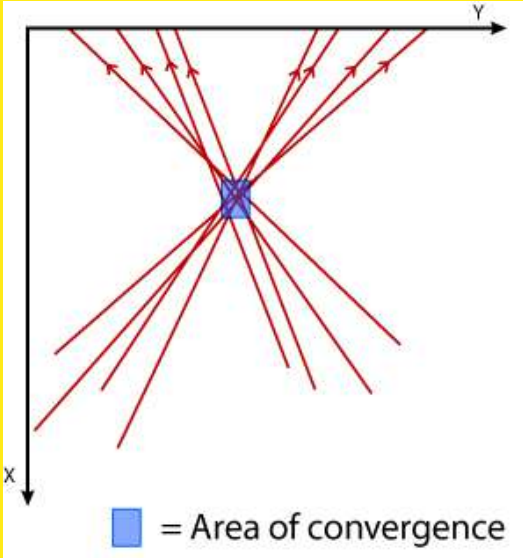
Reconstructing the crime

- With the evidence that is collected, the crime scene investigator attempts to reconstruct the crime.
- This involves trying to work out what events happened and the order that they happened.

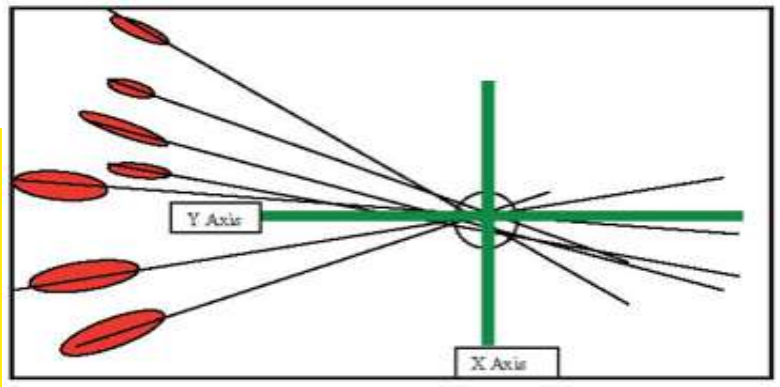
Image courtesy UWA PhD research student Mark Reynolds.

Interpreting Blood Spatter

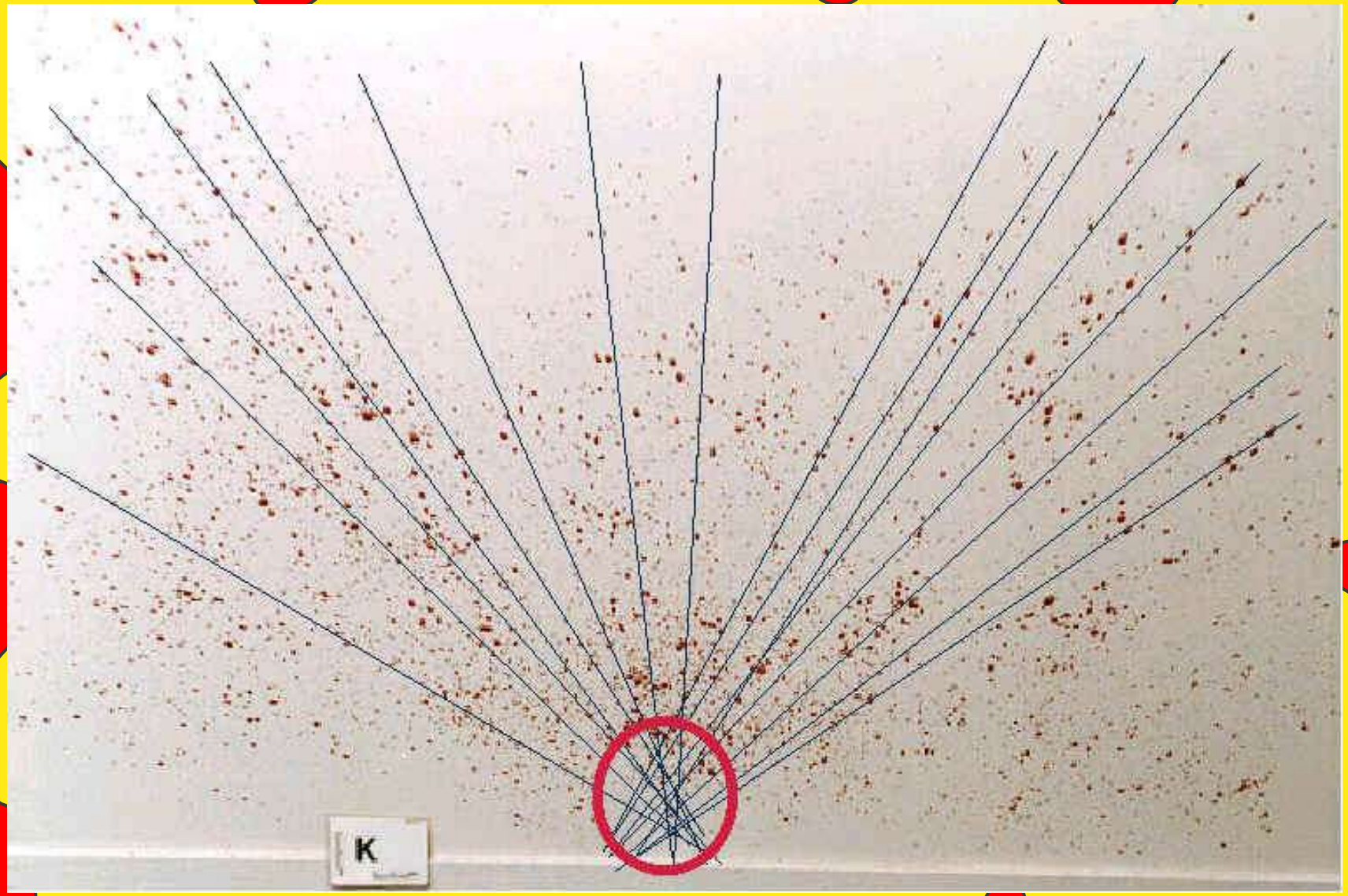
- Working with multiple droplets can tell where the victim was located when the crime was committed.



By drawing a line through the long axis of a group of bloodstains the point of convergence can be determined. Where the lines of the group of stains intersect one another the convergence point can be established



The area of convergence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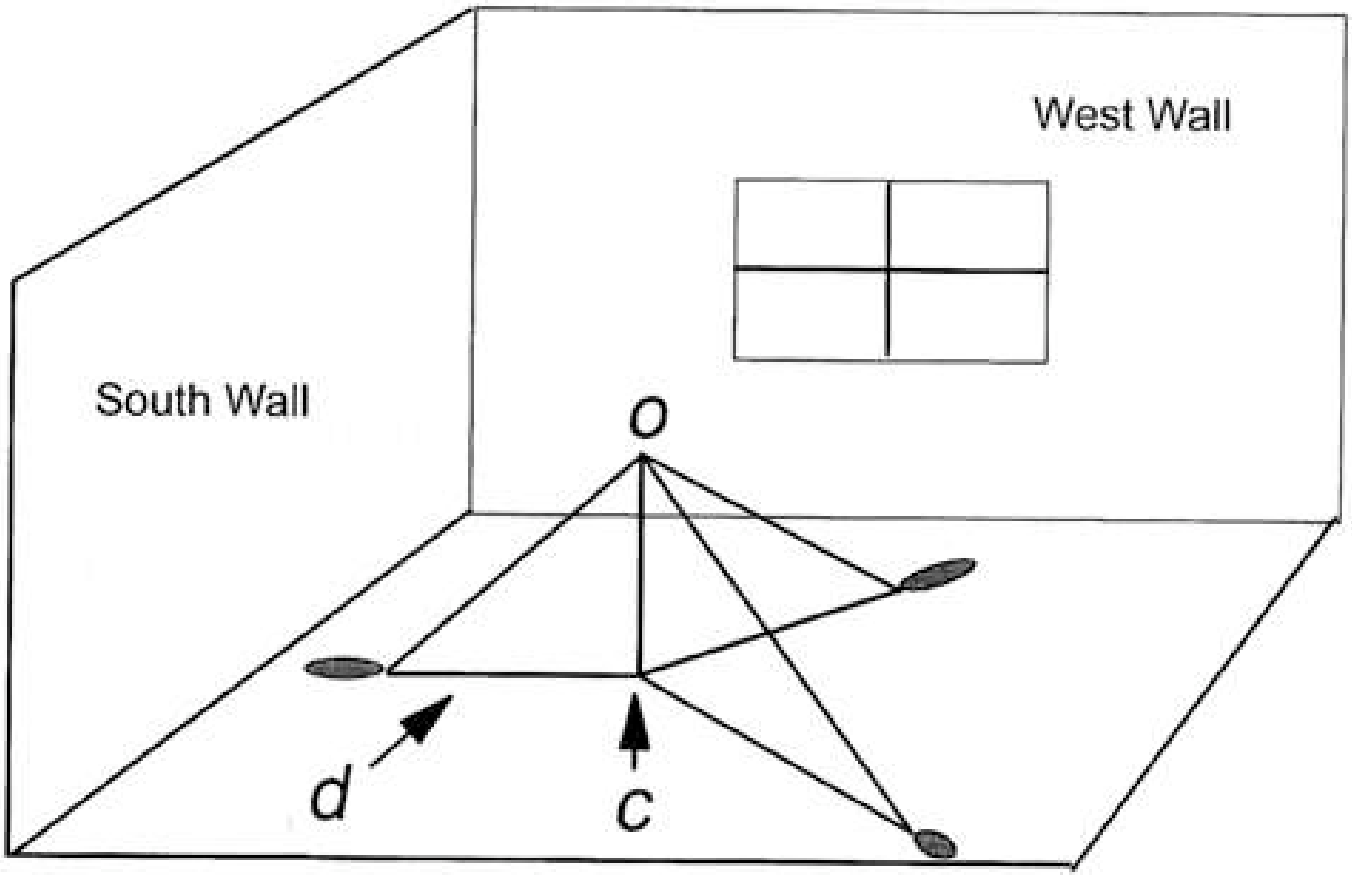
Origin of blood



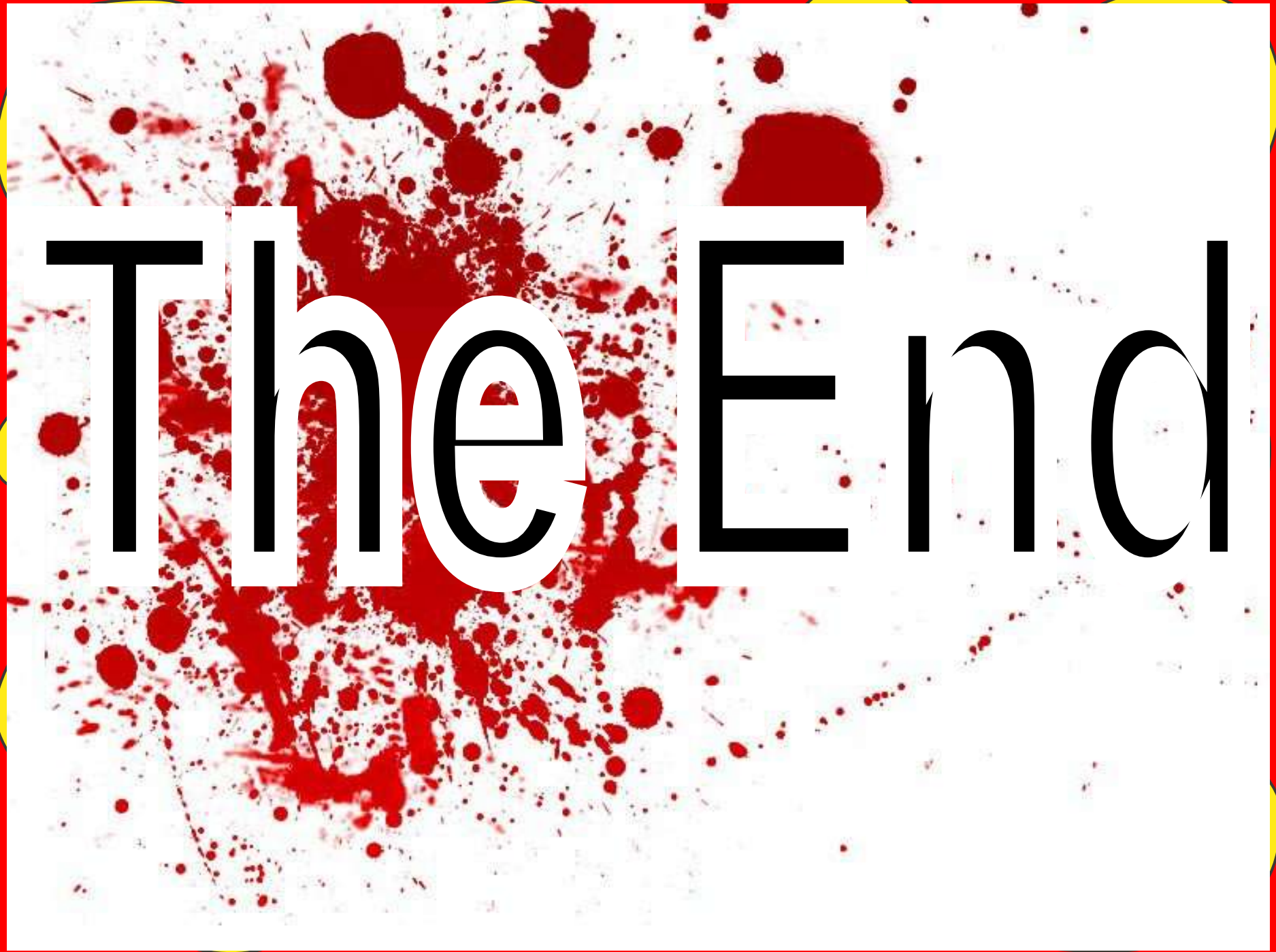
c = Point of convergence.
d = Distance from the base of the stain to the point of convergence.
o = Point of origin for the spatter.

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.

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.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