

# Blood and Blood Spatter

## Blood

### Chapter 11



# BLOOD OBJECTIVES

## You will understand:

- ✓ 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.

## You 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.

# Introduction

What does blood typing provides to an investigation?

- ❑ Blood typing provides class evidence
- ❑ DNA profiling provides individual evidence
- ❑ The truthfulness of an account by a witness or a suspect.
- ❑ The origin of the blood
- ❑ The angle and velocity of impact
- ❑ The type of weapon used

# Opening Questions: Blood

1. What do you think is the role of blood in the human body?
2. What makes up blood?
3. Do you think all human blood is the same?

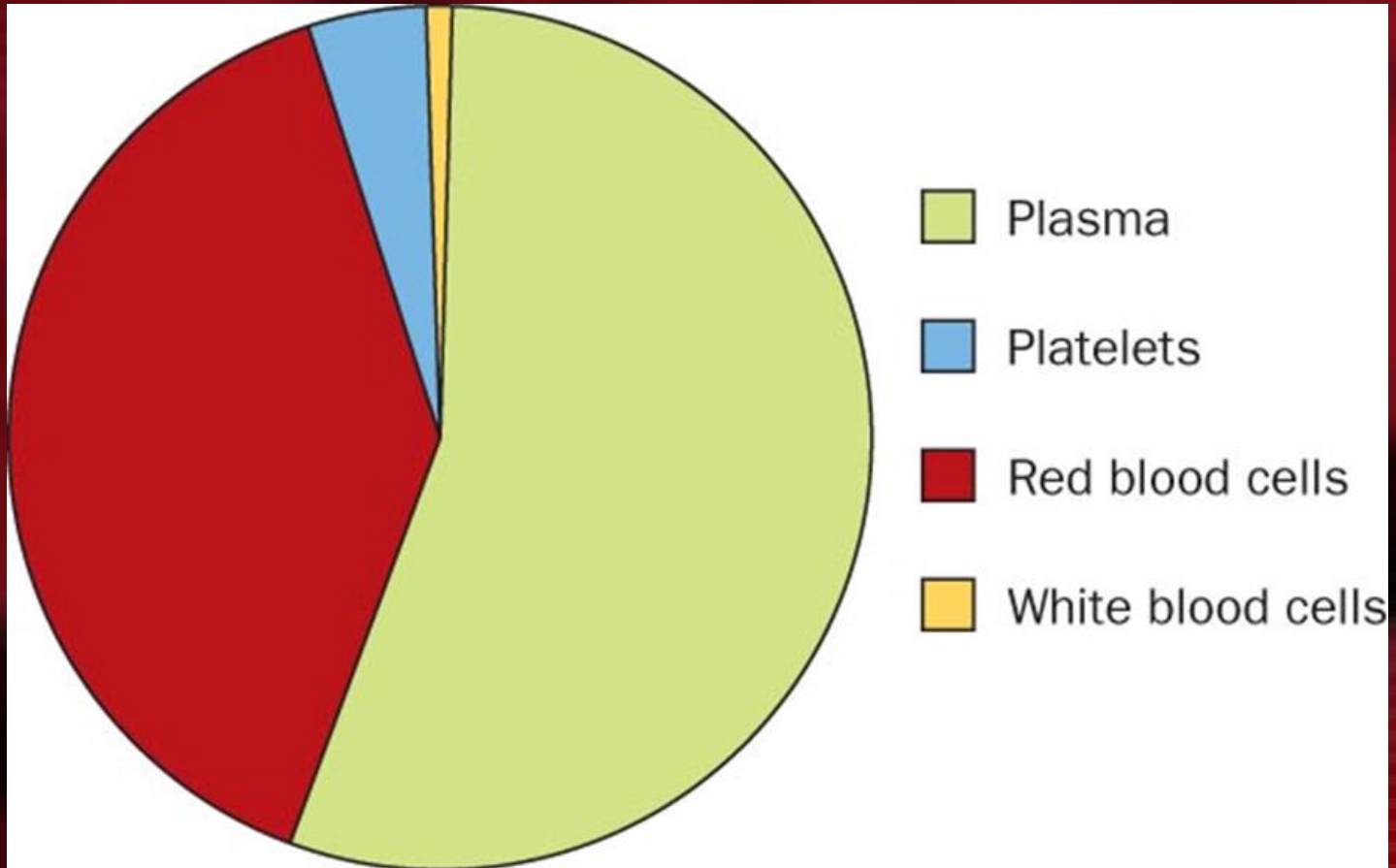
Explain

4. Do you think you could determine where the blood originated based upon the blood spatter stain?

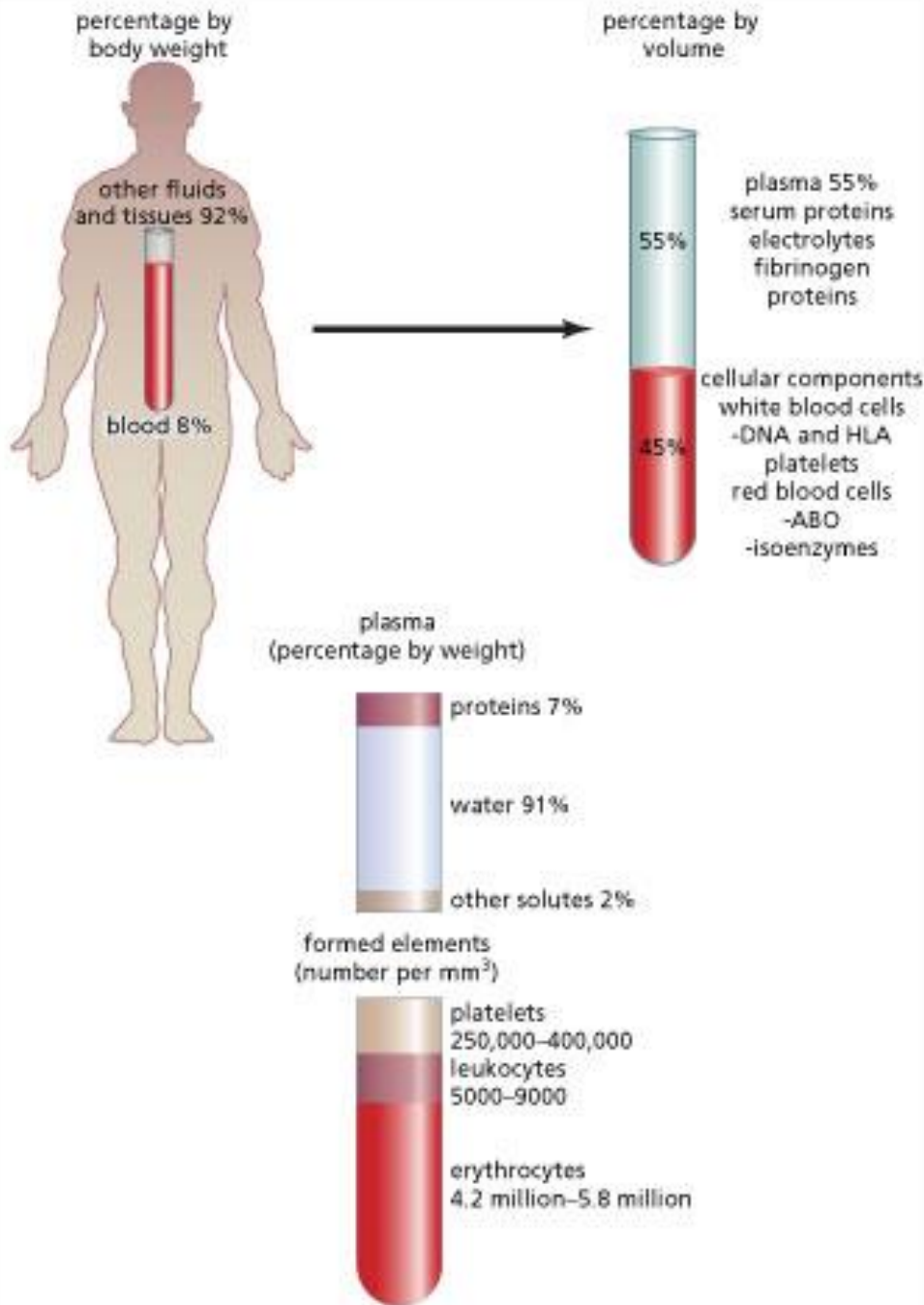
# Composition of Blood

- Plasma - a liquid suspending other blood components
- Red blood cells - (**erythrocytes**) carries oxygen to the body's cells and carbon dioxide away.
- White blood cells - (**leukocytes**) fights disease and foreign invaders and, alone, contain cell nuclei.
- Platelets – (**thrombocytes**) aids in blood clotting and the repair of damaged blood vessels.

# Composition of Blood



# Composition of Blood



A bag containing one unit of fresh frozen plasma

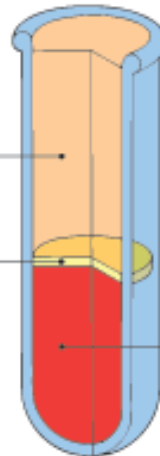
## Blood Components (Human): Composition

**Diagram showing composition of blood (average figures shown for a healthy body, but these can vary)**

**1** Plasma 54%

**2b** Leukocytes (white blood corpuscles) and platelets 1%

**2** Erythrocytes (red blood corpuscles) 45%



### Blood components

**3** Erythrocytes (red blood corpuscles)

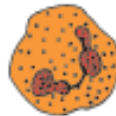


**4** Thrombocytes (platelets)

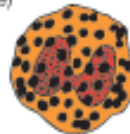


**5** Leukocytes (white blood corpuscles)

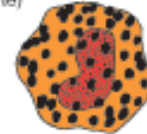
**5a** Neutrophil (granulocyte)



**5b** Eosinophil (granulocyte)



**5c** Basophil (granulocyte)



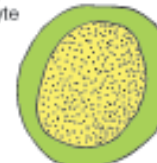
**5d** Monocyte



**5e** Small lymphocyte



**5f** Large lymphocyte





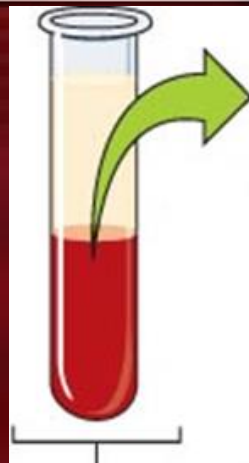
# Forensic Serology

Serology – involves the study of body fluids and stains at a crime scene, particularly blood.

If blood contains DNA matching:




- It could link a suspect to a scene
- It can prove a link between suspect, victim and crime

# Cellular Components of Blood



Separated blood elements

## Cellular elements 45%

Cell type	Number per $\mu\text{L}$ ( $\text{mm}^3$ ) of blood	Functions
Erythrocytes (red blood cells) 	5–6 million	Transport oxygen and help transport carbon dioxide
Leukocytes (white blood cells)  Basophil    Eosinophil    Lymphocyte    Neutrophil    Monocyte (Macrophage in tissue)	5,000–10,000	Defense and immunity
Platelets 	250,000–400,000	Blood clotting

# Genetics of Blood Types

- Your blood type is established before you are **BORN**, by specific **GENES** inherited from your parents.
- You inherit one gene from your **MOTHER** and one from your **FATHER**.
- These genes determine your blood type by causing proteins called **AGGLUTINOGENS** to exist on the surface of all of your red blood cells.



# What are blood types?

There are 3 alleles or genes for blood type: A, B, & O. Since we have 2 genes, there are 6 possible combinations.

## Blood Types








AA or AO = Type A

BB or BO = Type B

OO = Type O

AB = Type AB

## The ABO Blood System

Blood Type (genotype)	Type A (AA, AO)	Type B (BB, BO)	Type AB (AB)	Type O (OO)
Red Blood Cell Surface Proteins (phenotype)	 A agglutinogens only	 B agglutinogens only	 A and B agglutinogens	 No agglutinogens
Plasma Antibodies (phenotype)	 b agglutinin only	 a agglutinin only	NONE No agglutinin	 a and b agglutinin

# How common is your blood type?

TYPE	DISTRIBUTION	RATIOS	
O +	1 person in 3	38.4%	46.1%
O -	1 person in 15	7.7%	
A +	1 person in 3	32.3%	38.8%
A -	1 person in 16	6.5%	
B +	1 person in 12	9.4%	11.1%
B -	1 person in 67	1.7%	
AB +	1 person in 29	3.2%	
AB -	1 person in 167	0.7%	3.9%

<http://www.bloodbook.com/type-facts.html>

# Blood Transfusions

A **blood transfusion** is a procedure in which blood is given to a patient through an intravenous (IV) line in one of the blood vessels. Blood transfusions are done to replace blood lost during surgery or a serious injury. A transfusion also may be done if a person's body can't make blood properly because of an illness.

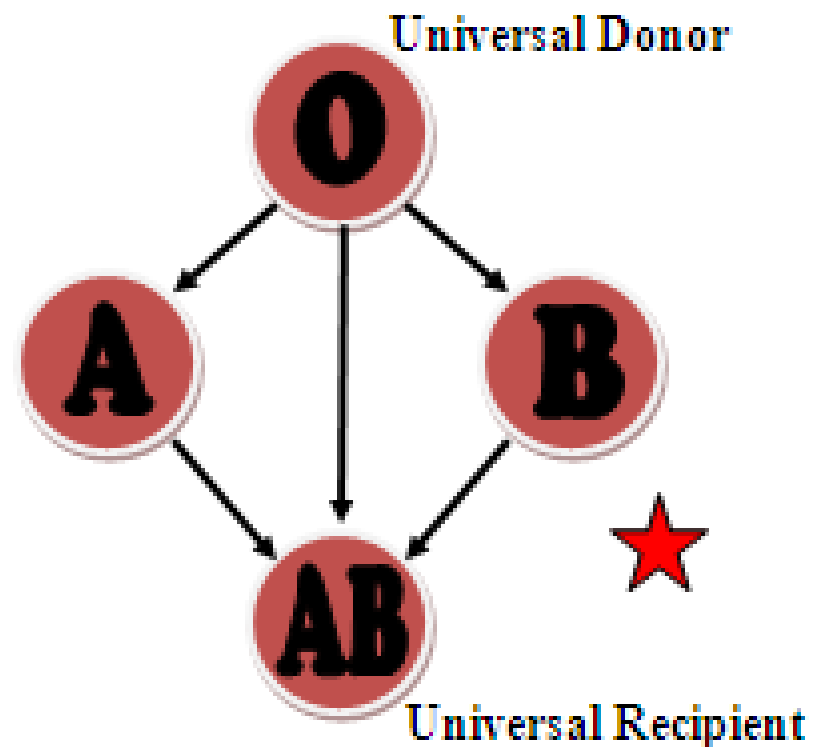
## Who can give you blood?

People with **TYPE O** blood are called **Universal Donors**, because they can give blood to any blood type.

People with **TYPE AB** blood are called **Universal Recipients**, because they can receive any blood type.

Rh + → Can receive + or -

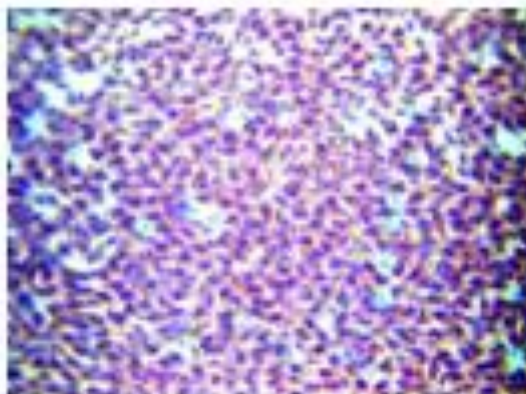
Rh - → Can only receive -



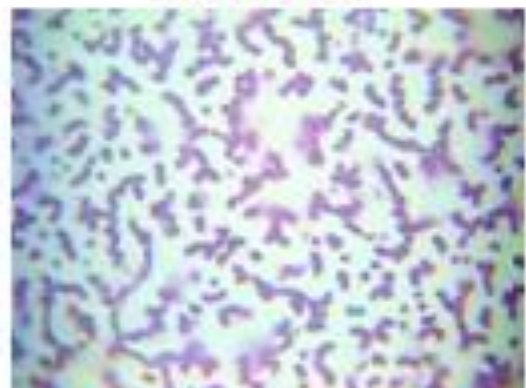
# Blood Evidence

- Blood samples – Can be analyzed to determine **blood type** and **DNA**, which can be matched to possible suspects.
- Blood droplets – Can be analyzed to give clues to the location of a **crime**, movement of a **victim**, and type of **weapon**.
- Blood spatter – Can be analyzed to determine **patterns** that give investigators clues to how a crime might have happened.

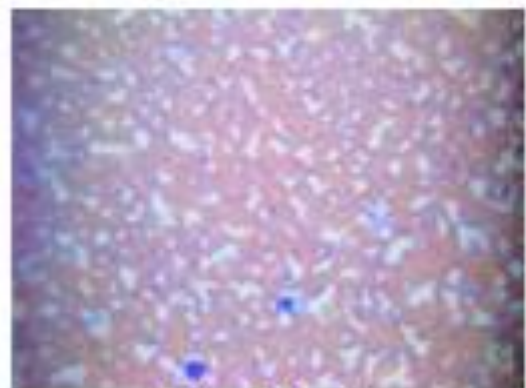
# Microscopic Views



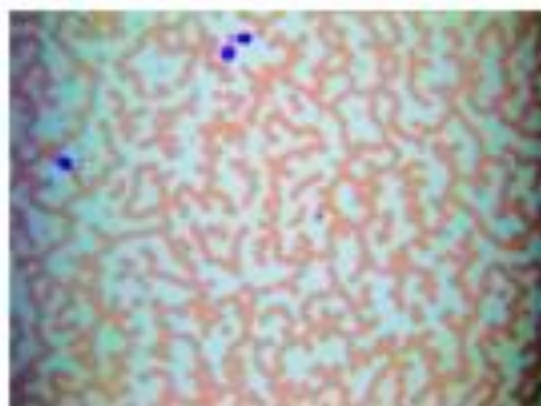
Bird Blood



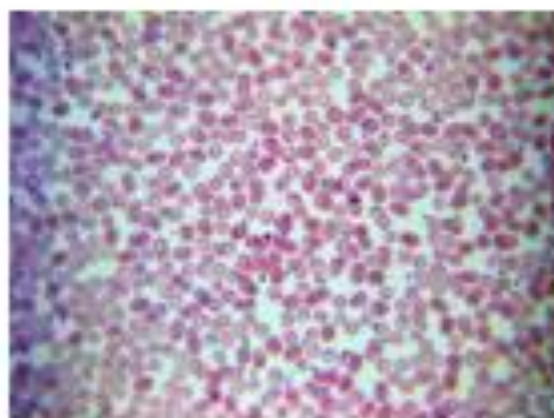
Cat Blood



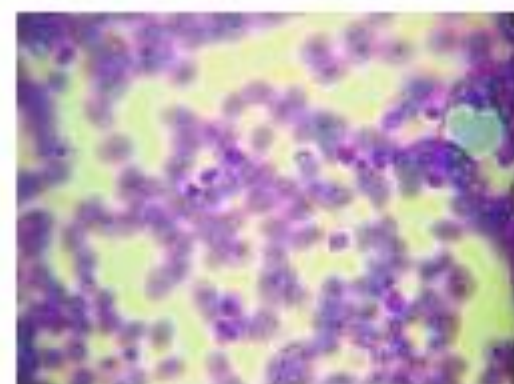
Dog Blood



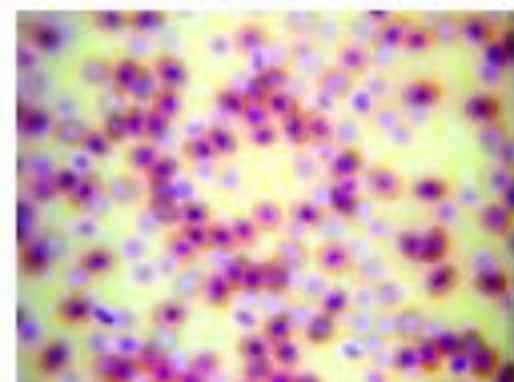
Horse Blood



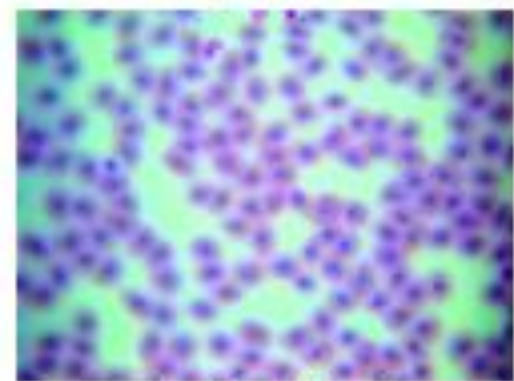
Human Blood



Fish Blood



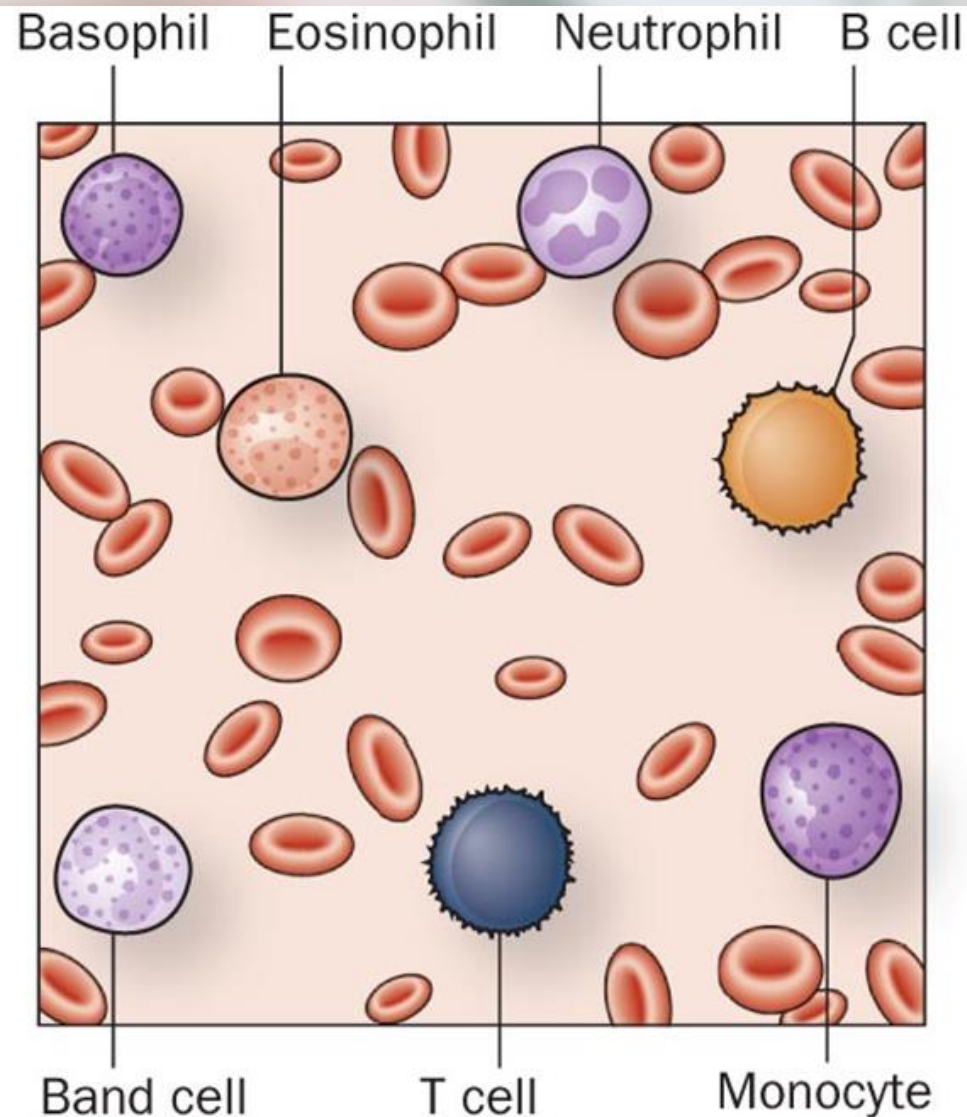
Frog Blood



Snake Blood



# History of DNA Profiling



- ✓ In 1982 white blood cells were used as a source of DNA by Dr. Alec Jeffreys to produce the first DNA profile.

# How the RFLP Process Works

©2008 HowStuffWorks

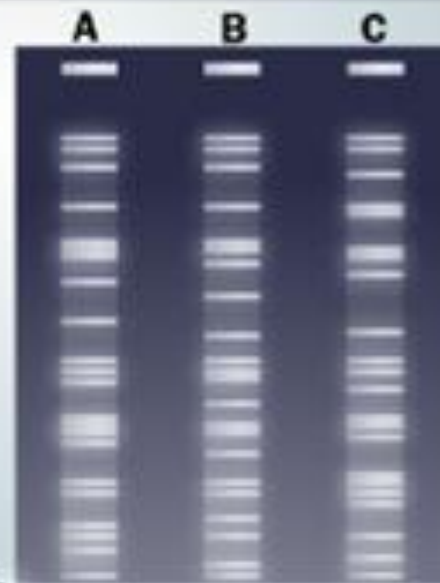
The first method for creating a DNA profile was RFLP, or restriction fragment length polymorphism.

RFLP is not used as often today because it requires a large sample of DNA -- as much as 25 hairs or a nickel-sized spot of bodily fluid -- and can take as long as a month to complete.

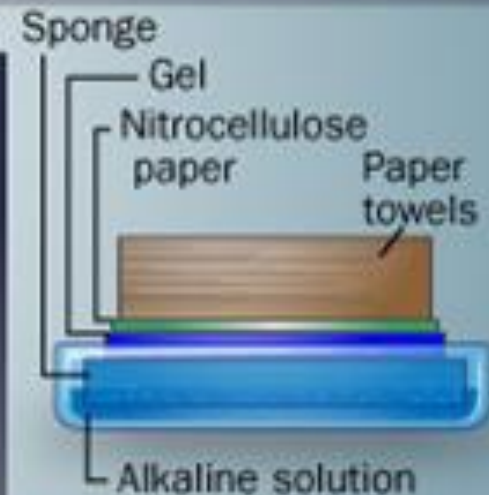
It also requires examining multiple sections of the DNA strand to find variations, which is time-consuming and leaves more room for human error.



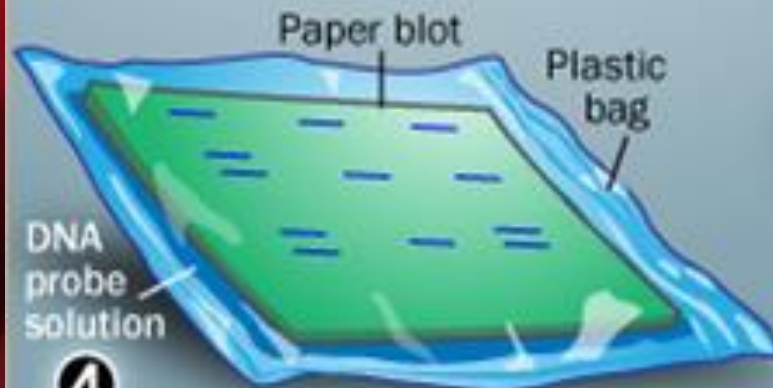
**1** DNA Samples with added restriction enzymes produce restriction fragments.



**2** Electrophoresis separates the restriction fragments. Each sample forms a characteristic pattern of bands.



**3** Alkaline solution is pulled upward through the gel to a sheet of nitrocellulose laid on the top of it, transferring the DNA to the paper.



**4** The paper is exposed to a solution containing radioactively-labeled probe.



**5** A photographic film laid on top of the paper is exposed by the radioactivity in the bound probe to form an image corresponding to the DNA bands.

# Questions

Copy and answer these questions:

1. What part of blood can be used for DNA analysis?
2. How long has DNA analysis been possible?
3. Why is DNA an important tool for forensic scientists?

Answers:

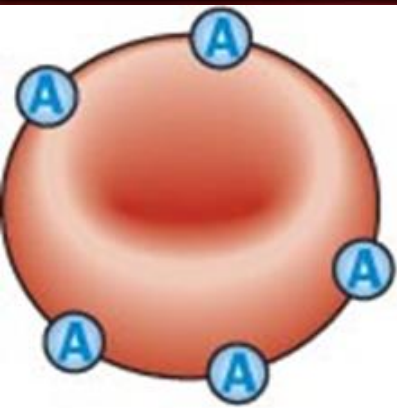
1. White blood cells
2. Since 1982 – (29 years)
3. Because it determines with a high degree of certainty the identity of an individual.



# Discovery of Blood Types

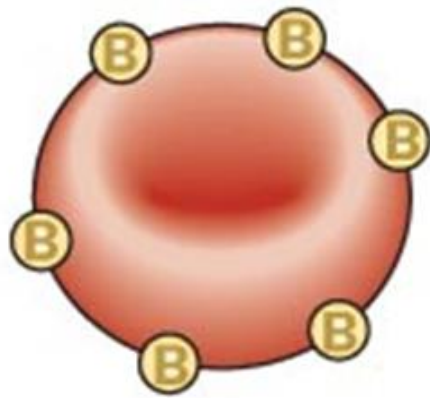
- Discovered in 1900 by Karl Landsteiner.
- Identifies the presence or absence of particular proteins embedded in the cell.
- In 1901, Landsteiner described the A and B proteins found on red blood cells.
- The Rh factor (protein) were also identified.
- An antibody reaction test is used to identify each blood type.

# A and B Proteins



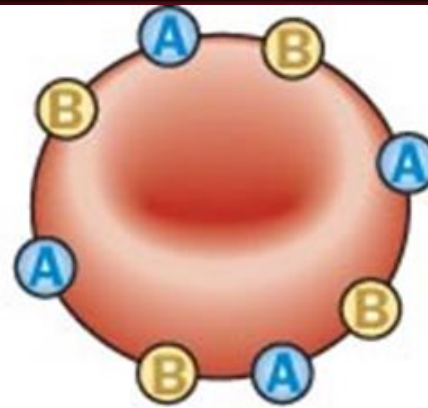
Type A

42%



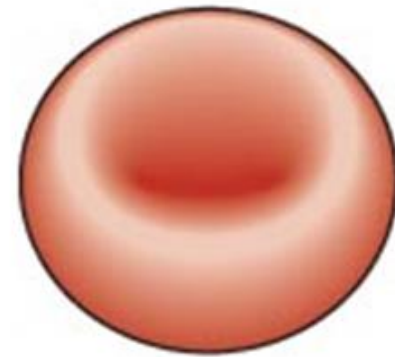
Type B

12%



Type AB

3%



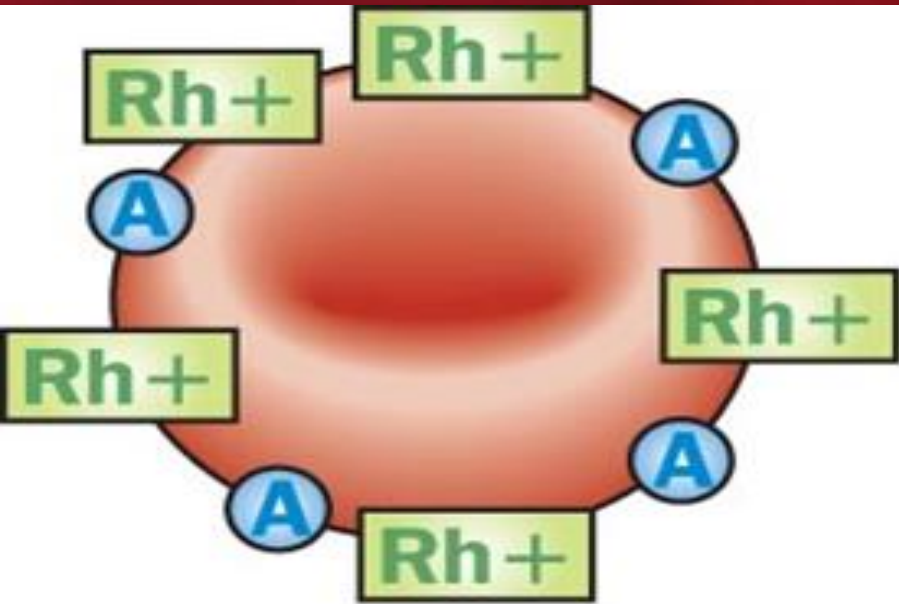
Type O

43%

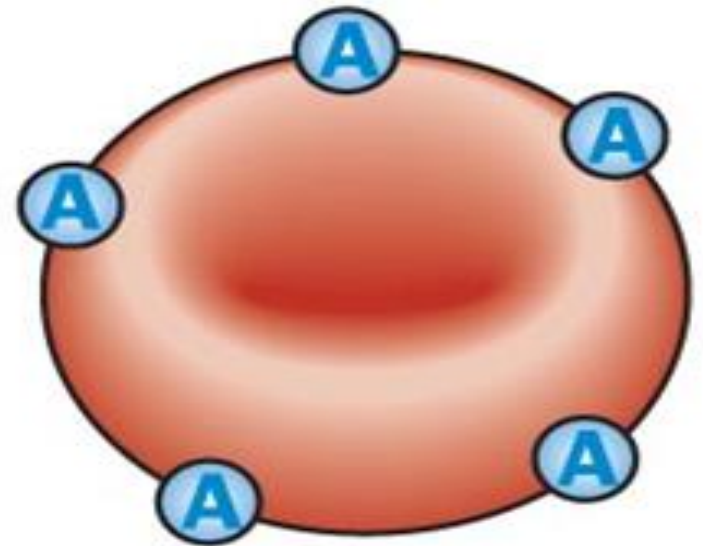
of the population in the United States

# Rh Factor

85% of the human population has a protein called Rh factor on their red blood cells.



Protein A present  
Rh protein present  
Type A+



Protein A present  
Rh protein absent  
Type A-



Rhesus monkeys have an important history with humans and have aided a great deal of medical and scientific research. Rhesus antigens found in their blood enabled doctors to identify the different human blood groups. These primates also preceded humans into space.

Cayo Santiago is a small island (38 acres) just off the southeastern coast of Puerto Rico. Cayo Santiago is a research field station which is home to approximately 800 free-ranging rhesus macaques. The colony is run and maintained by the Caribbean Primate Research Center (CPRC) and the University of Puerto Rico, Medical Sciences Campus.

The monkeys currently living on Cayo are divided into a few natural social groups. The individuals in the current colony are the direct descendants of 409 monkeys who were brought to the island in 1938. Monkeys are fed a diet of Purina monkey chow from three feeding locations on the island. The population also eats a variety of other indigenous foods, including leaves, fruits, flowers, and soil. Monkeys have access to water at a number of locations. Because of almost 70 years of research at this field site, subjects are well habituated to human experimenters. We have tested subjects from the Cayo Santiago population for the past nine years.



At no point can you step onto the island. These are wild animals with Herpes B and they may attack.



















# Naming of Blood Types

- A person's blood type is based on the presence or absence of the AB and Rh proteins.
- The presence of different blood types was not discovered until 1901.
- Wrong blood = cause clumping = death

# Blood Type

Donor Blood Type

	O	A	B	AB
O				
A				
B				
AB				

Recipient Blood Type

# 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

# Blood Donation



# Blood Spatter



# Blood Spatter

- A grouping of bloodstains composes a blood-spatter pattern.
- It helps to reconstruct the series of events surrounding a shooting, stabbing, or beating.
- [Blood Spatter video clip](#)

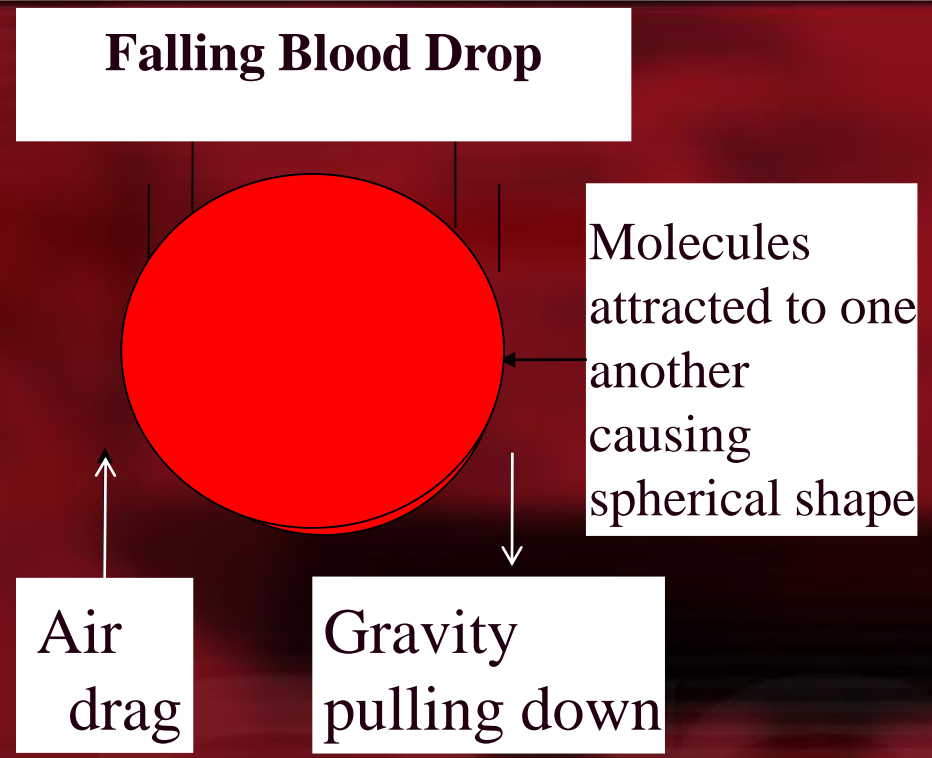
# Blood Spatter Analysis

Given BSP, it is possible to determine:

1. direction blood was traveling
2. angle of impact
3. point of origin of the blood
4. manner of death

# How does forces of gravity, air resistance (friction), cohesion, adhesion, and surface tension act on blood?

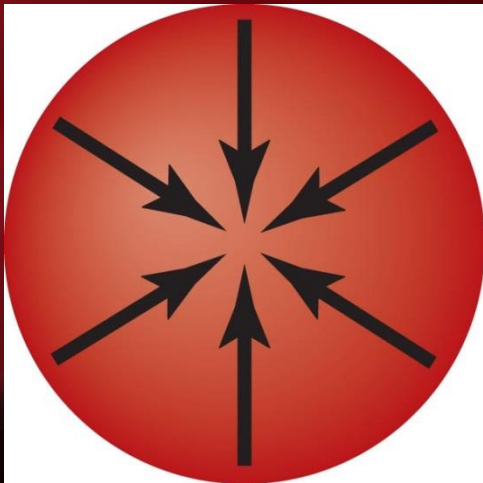
- Gravity
- Air Resistance
- Surface Tension, in the case of any fluid containing a high % of H<sub>2</sub>O



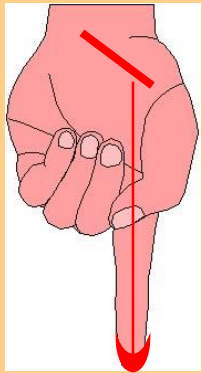


# Cohesion

- Blood is cohesive.
- Blood is attracted to similar blood mixtures and tends to stick together as it falls.



Cohesive forces in a blood droplet resist droplet flattening.



# Dripping Blood

Blood trickles downwards

Blood drop grows until  $Wt (G) > S.T.$

Single drop breaks free (teardrop shape)



Surface tension pulls in vertically



And horizontally

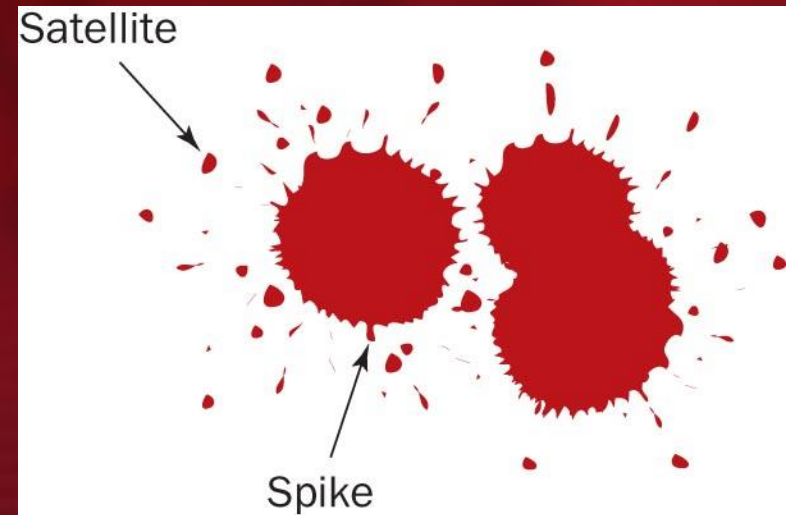
Shape settles into sphere (0.05 ml)

Does not break up until impact



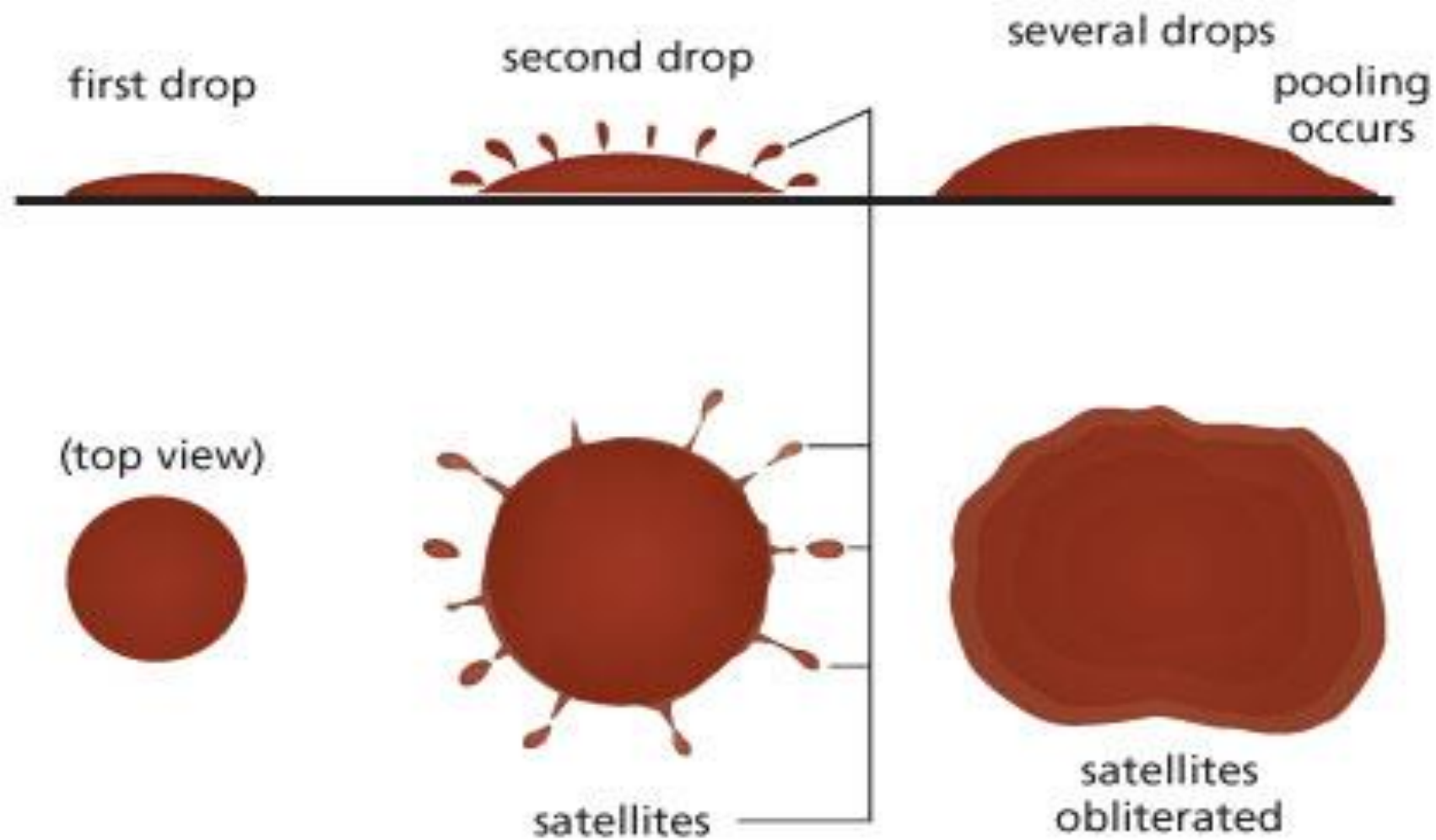
# Blood Spatter Analysis

- Satellite droplets
  - When blood falls from a height, or at a high velocity, it overcomes its natural cohesiveness, and separates from the main droplet.
- Spiking patterns
  - Form around the droplet edges when blood falls onto a less-than-smooth surface.

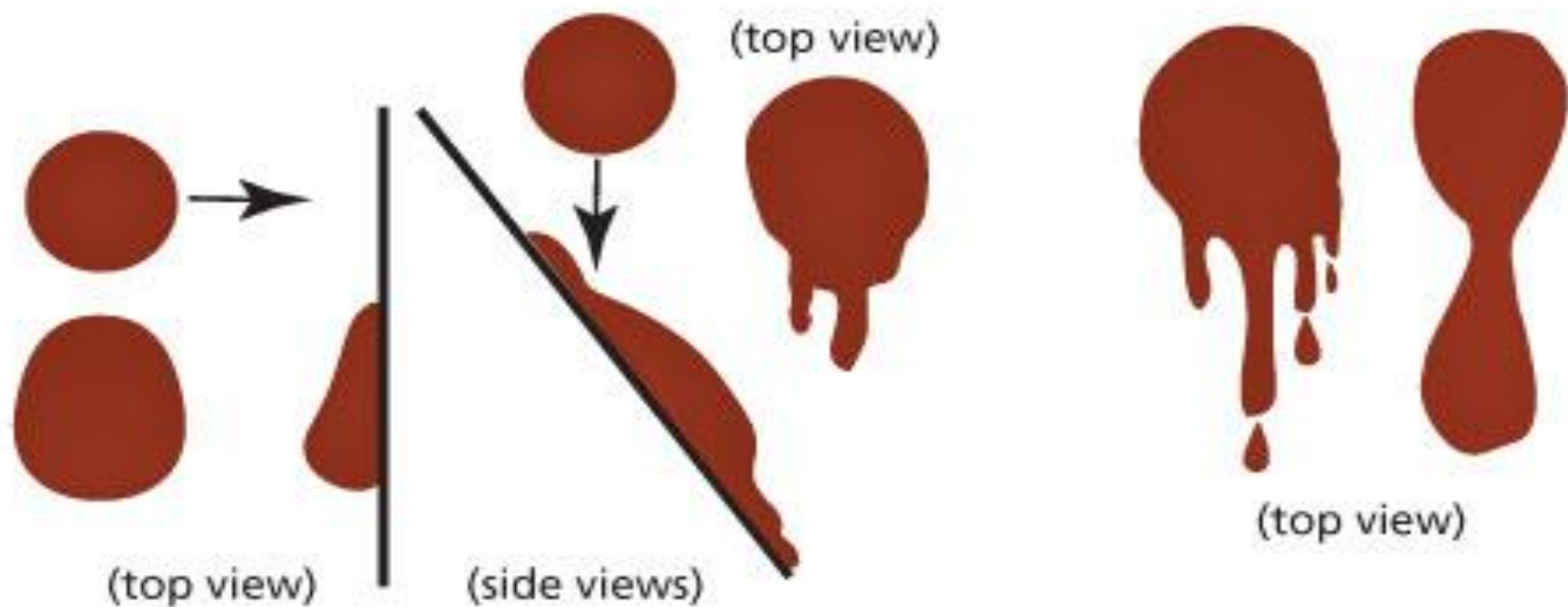


Notice that spikes are still connected to the main droplet whereas satellites are totally separated.

satellite formation and obliteration  
(side view)



impact on vertical and tilted surfaces—gravity effects



# Effect of Target Surface

## Blood Spatter animations



**Spreads out smoothly**



**ST of spreading edge is broken by irregular surface**



# Blood Spatter Analysis

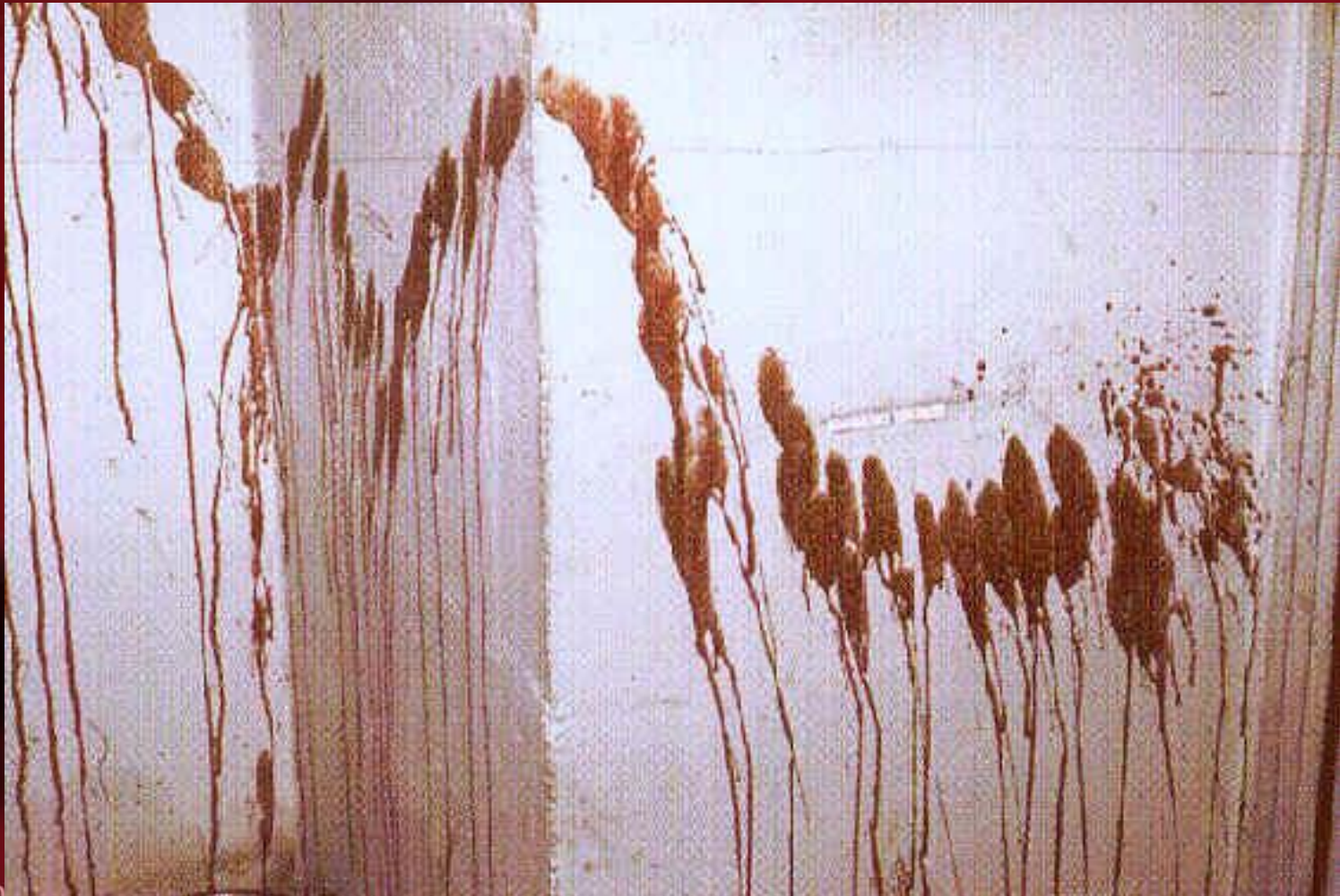
In 1902, Dr. John Glaister describe the six patterns into which blood spatters could be classified. They include:

## 1. Passive fall



## 2. Arterial spurts or gushes

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





## 3. Splashes



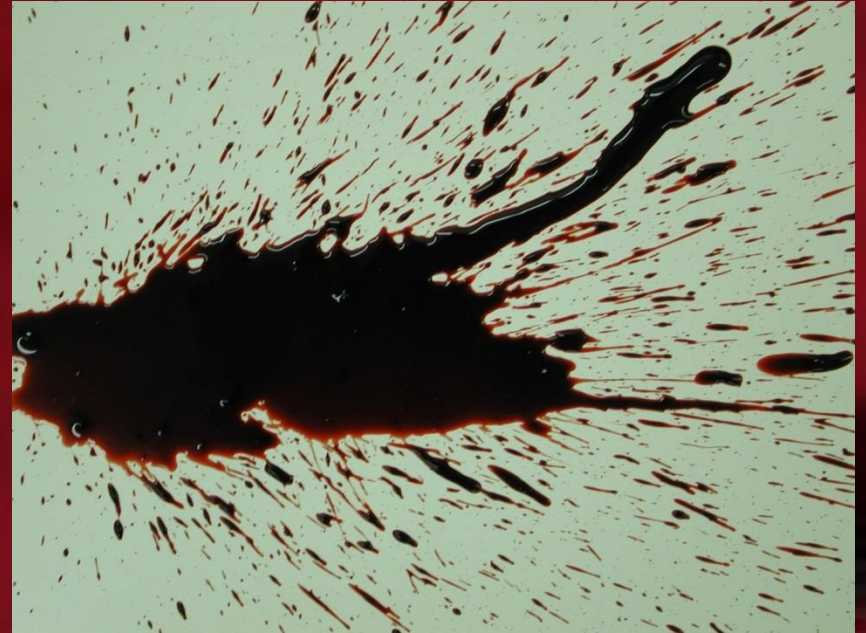
## 4. Smears



## 5. Trails of Blood



## 6. Pools of Blood



# Effect of Angle of Impact

- The size and shape of blood droplets help identify the direction from which the blood originated.

Effect of Angle of Impact on Bloodstain Pattern

Angle of Impact

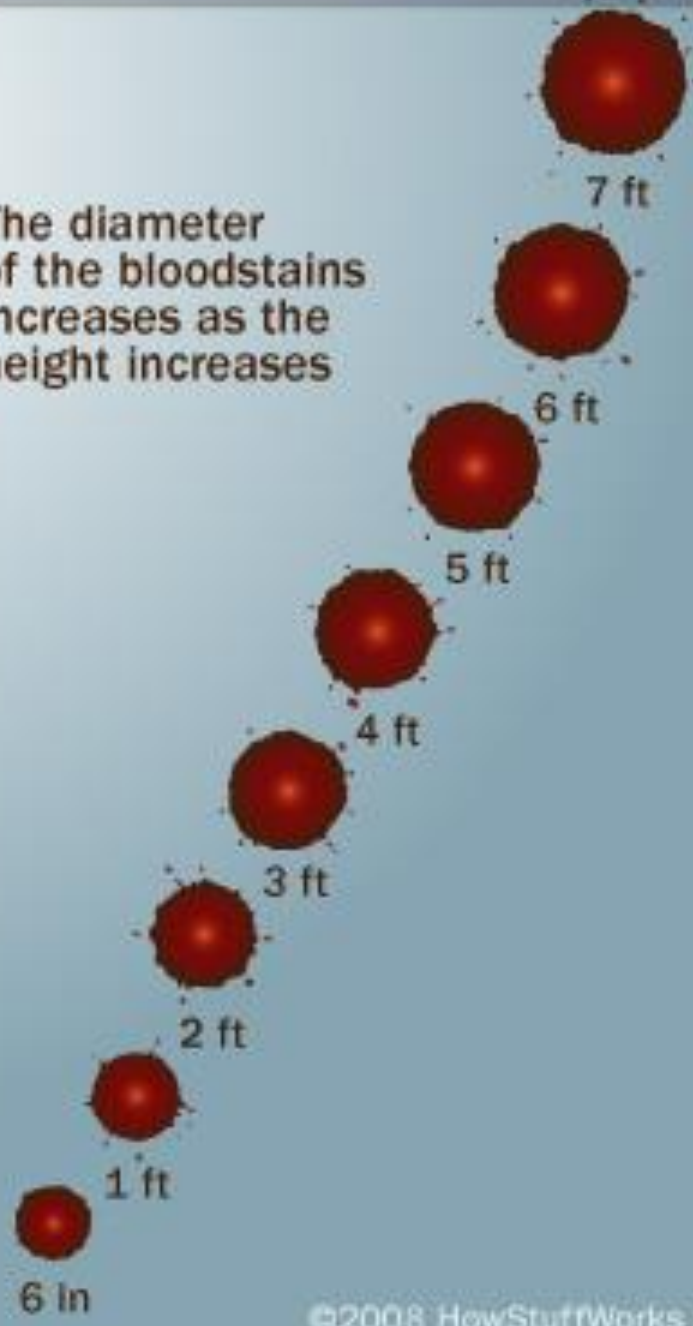
Appearance



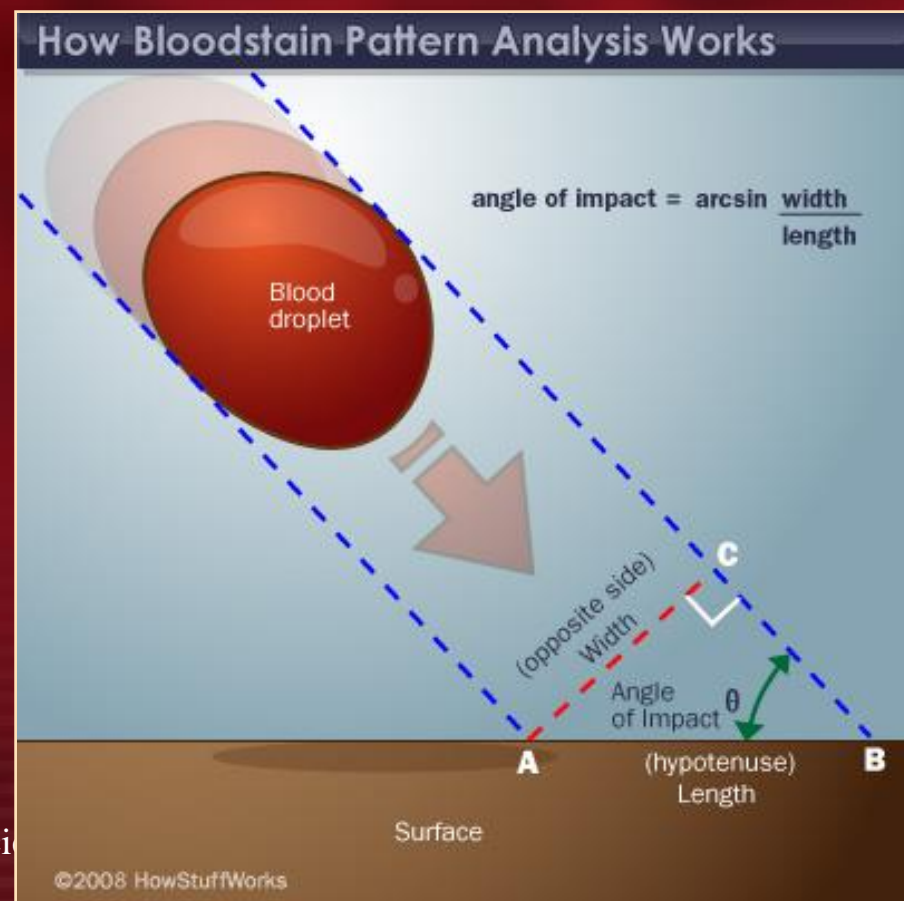
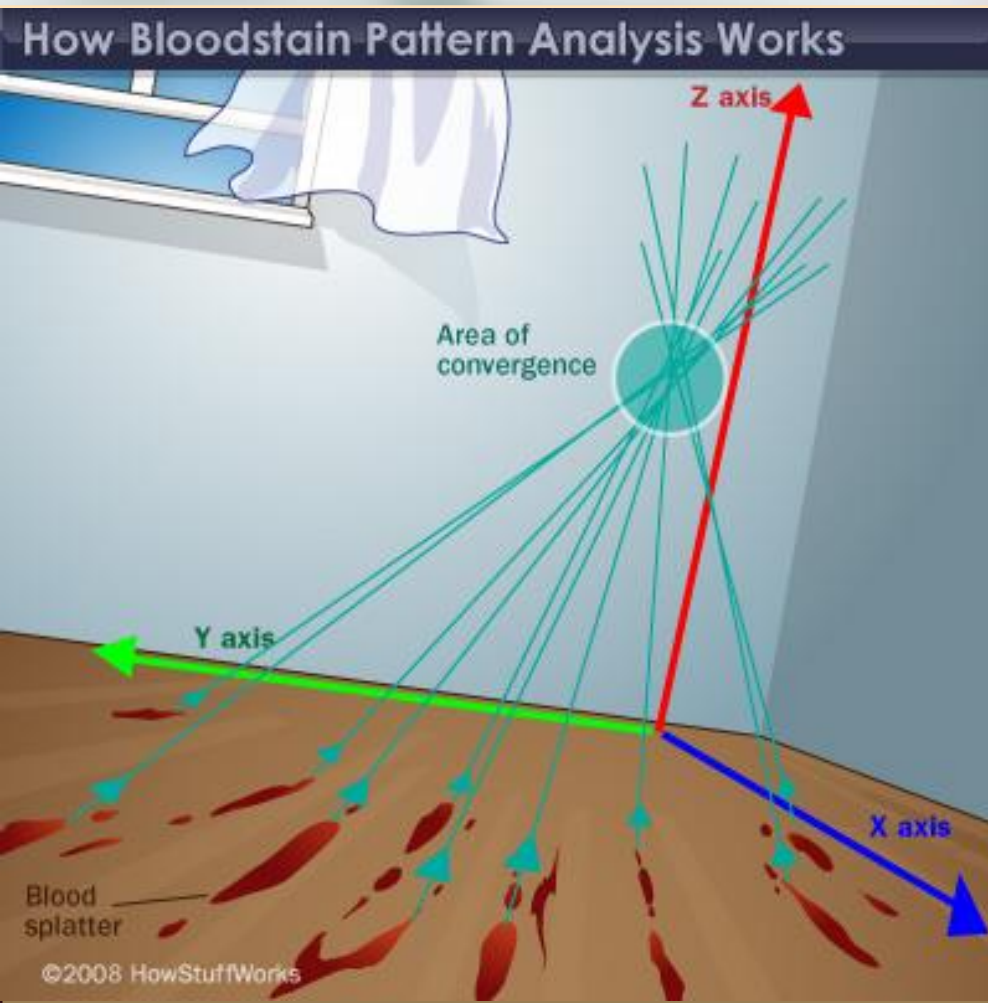
# Low Bloodstain Pattern Analysis Works



The diameter of the bloodstains increases as the height increases



No change in diameter beyond 7 ft.



2009©Forensic Sci

haematology

# How Bloodstain Pattern Analysis Works

## Blood Drop Elongation



# Direction of Movement

Tail shows  
direction



# Spatter Patterns

- Spatter patterns can help the investigator determine the type of wound.
- A fine mist spatter is produced by a high velocity impact, such as a gunshot wound.
- A beating with a pipe will produce blood cast off with a lower-velocity pattern.



# Blood Spatter Categories

Categories are based on how fast the blood drops were traveling when they hit the target surface.

- **Low-velocity Impact Spatter**
- **Medium-velocity Impact Spatter**
- **High-velocity Impact Spatter**

## High-velocity Impact Spatter

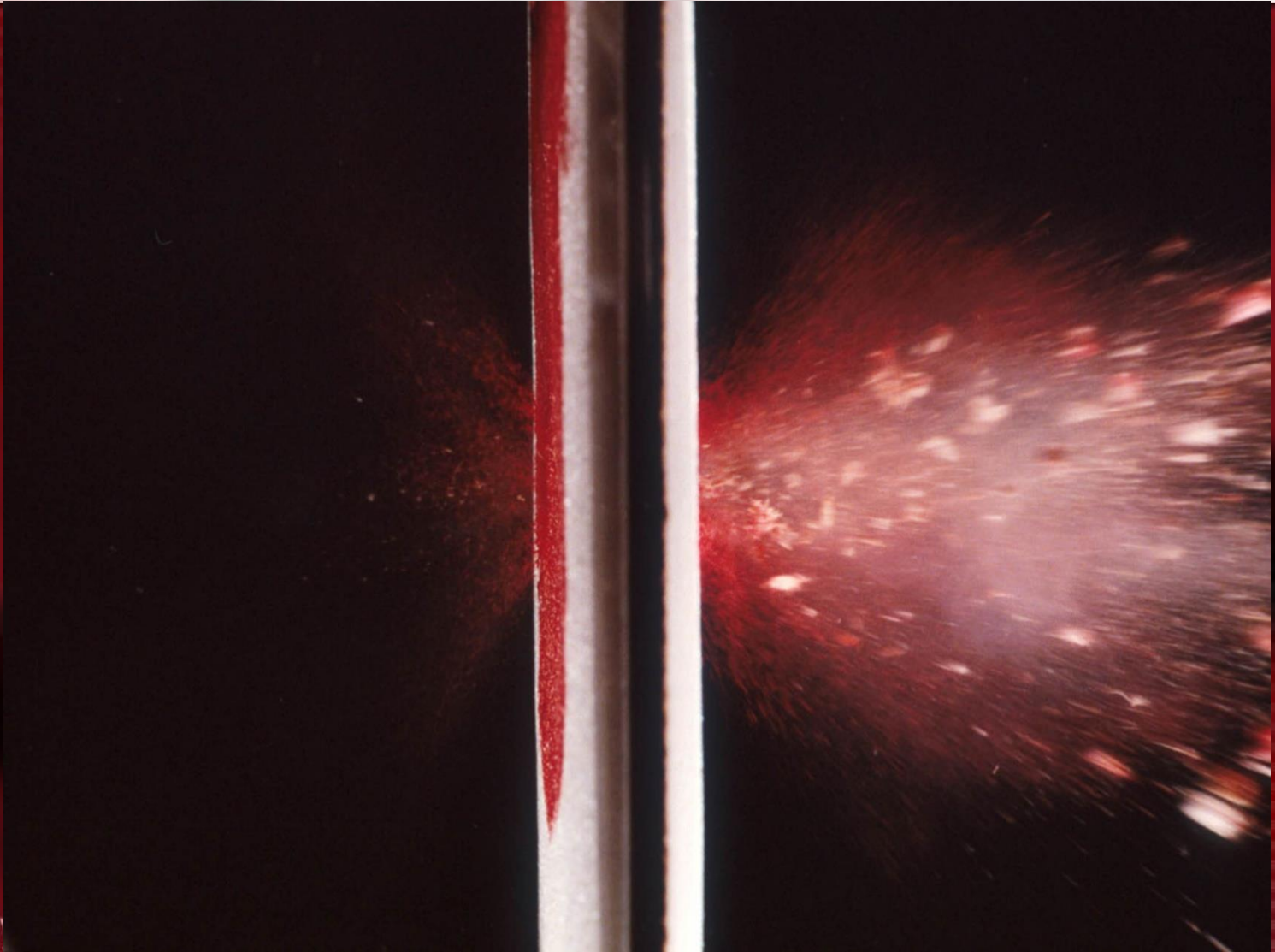


Blood droplets  
have been highly  
spattered.

Measure less than  
2 mm.

Associated with  
high speed  
collisions and  
gunshot wounds.

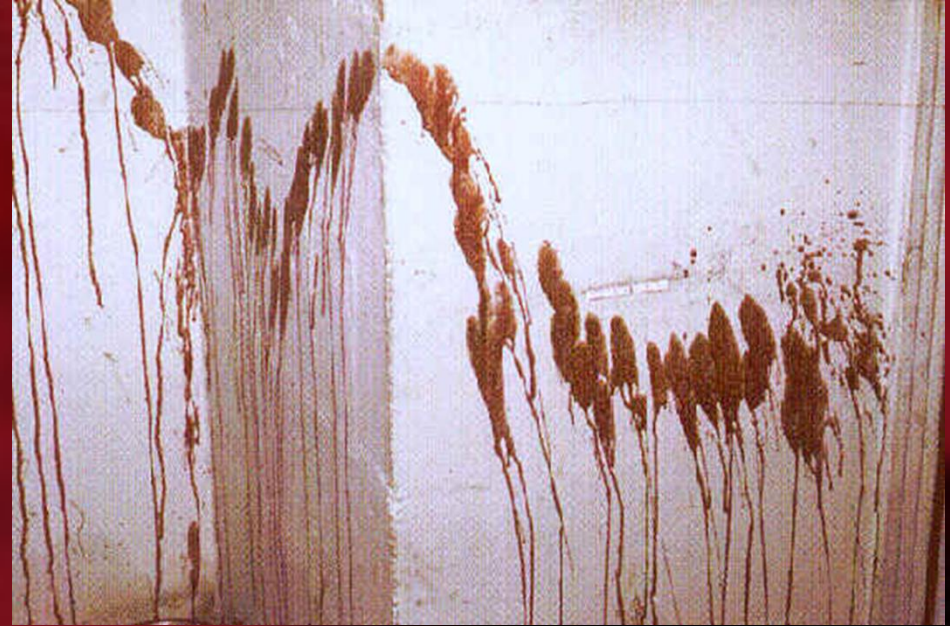
# High-velocity Impact Spatter



# Medium-velocity Impact Spatter

- Most drops are broken into smaller droplets of 2 to 4 mm resulting from a force of greater than 25 feet/sec (terminal velocity)
- Most common types are:
  - **Projected blood** - blood will gush onto surface. Sharp edges and be on the direction on the surface in which blood has projected.
  - **Repetitive dripping pattern** - blood dripping down into a pool of blood.
  - **Cast-off bloodstain pattern** - an already bloody object is swung through the air, casting off droplets of blood as it arcs through the air. Linear pattern

# Medium-velocity Impact Spatter



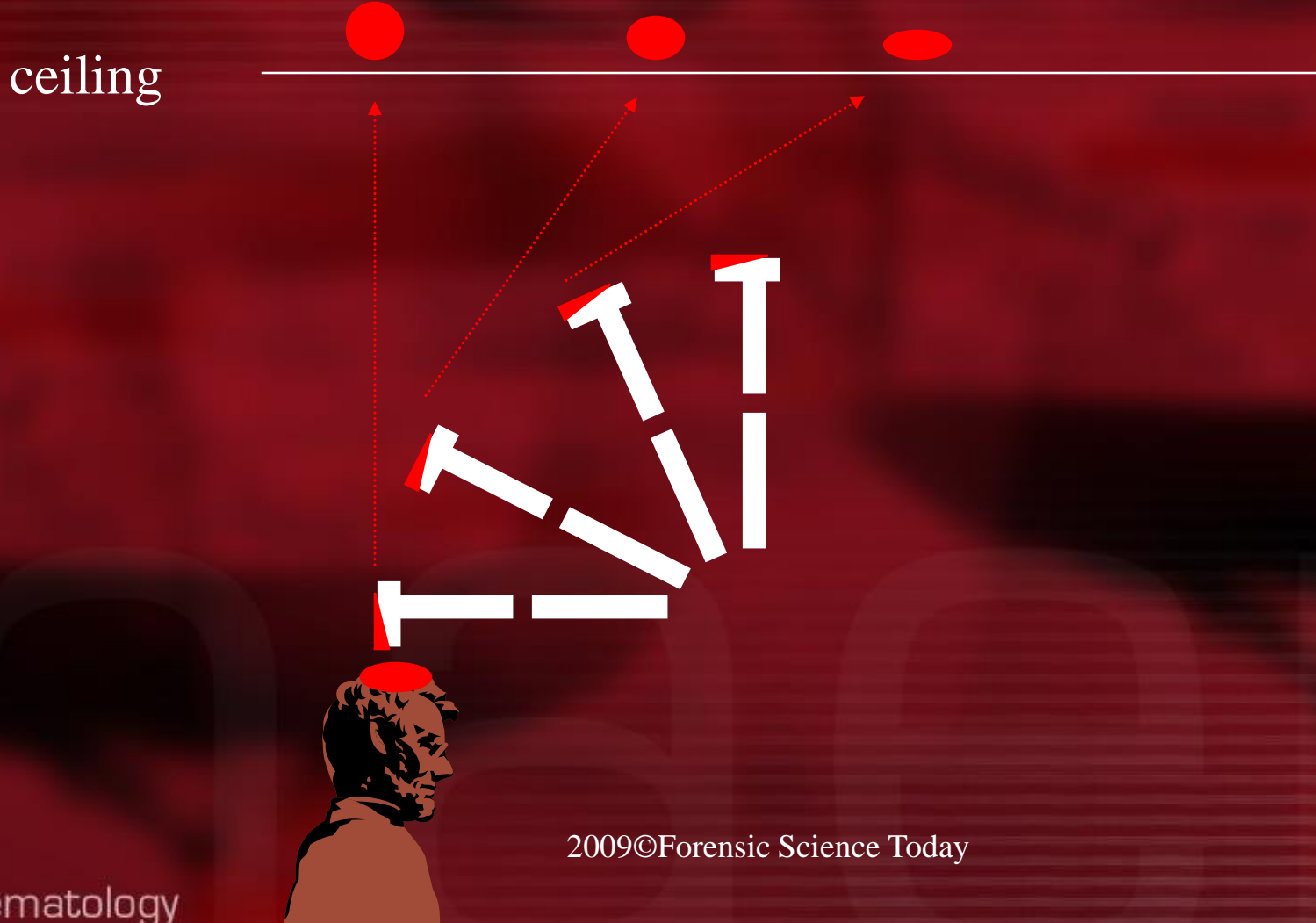
Projected Blood

# Cast-off from Weapon

Cast-off bloodstain pattern



# Cast-off from Weapon

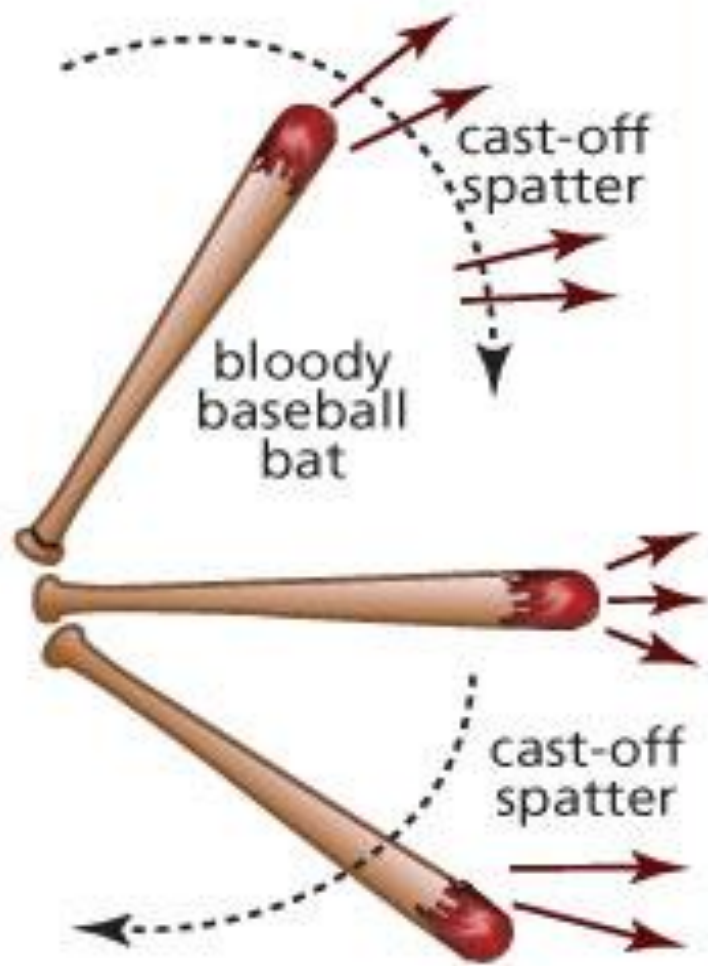


ceiling

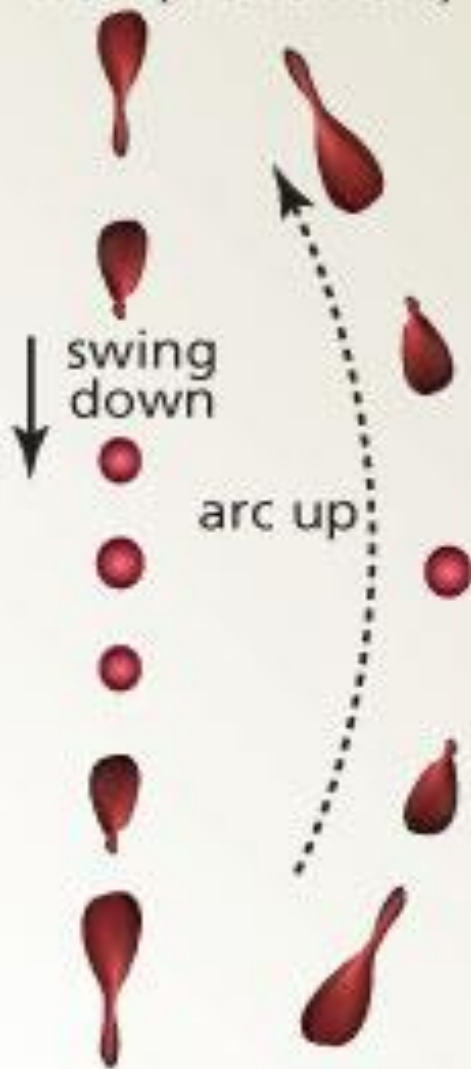
# Cast-off & medium velocity spatter







wall (front view)

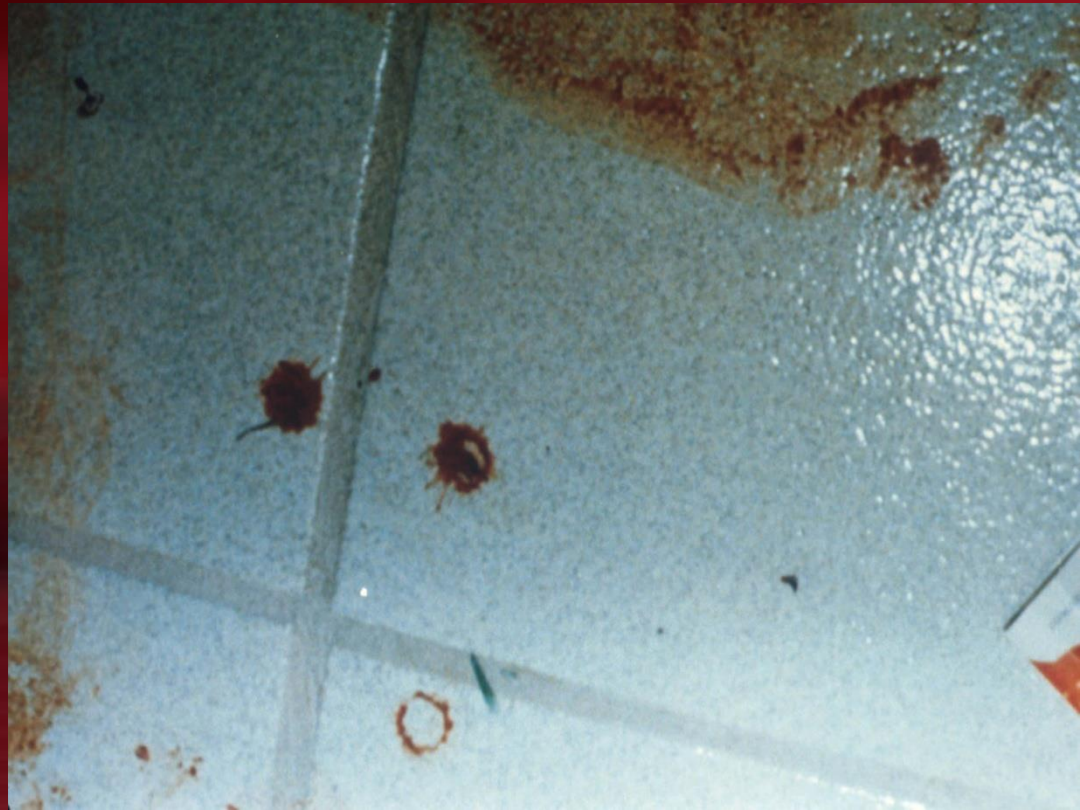


impact spatter



# Low-velocity Impact Spatter

- Most blood drops remain full-sized.
- Original drops are not broken into small drops.
- Drop diameter is 4mm or more.



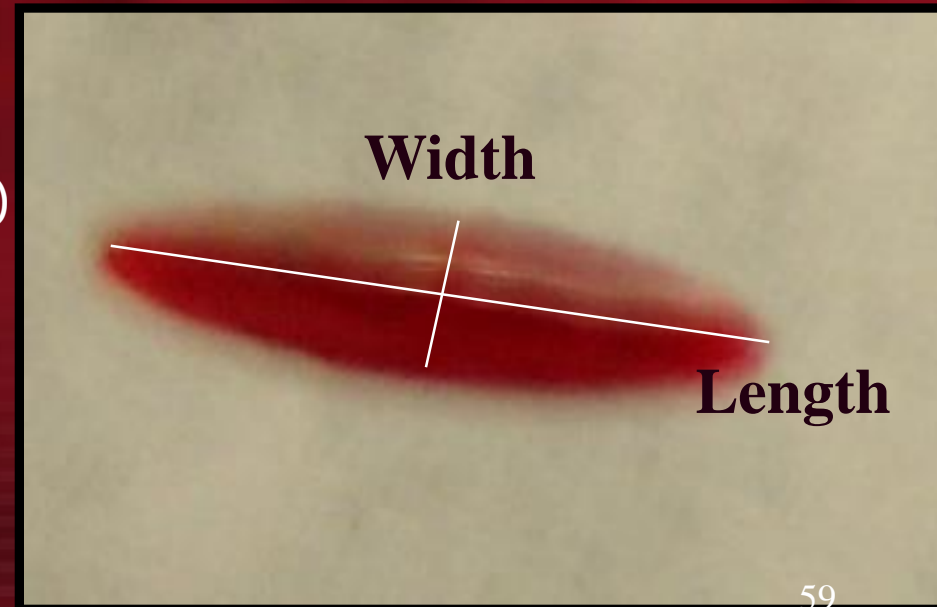
# Point of Origin

- Point of origin can be determined by the mathematical relationship between the width and length of blood droplets.

Calculate with two measurements

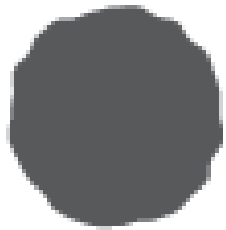
Length and width of stain

Impact Angle  $\theta = \sin^{-1}(\text{length}/\text{width})$



# Shapes of Blood Drops

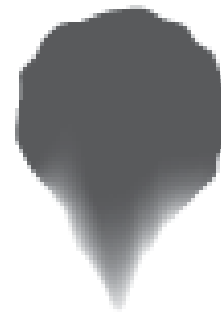
## SHAPES OF BLOOD DROPS



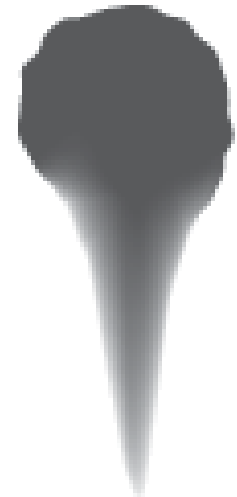
Low height  
Low velocity



High height  
High velocity



Low angle  
Low velocity



High angle  
High velocity

© Infobase Publishing

How will the point of impact compare with the rest of a blood pattern?

**Darker and wider than the rest of the drop.**

# Questions:

- What four properties of a crime scene can be identified from blood spatter?
  1. Direction blood was traveling
  2. Angle of impact
  3. Point of origin
  4. Manner of death
- Can blood spatter be used to identify a victim or suspect? Explain your answer.

Yes. By using blood spatter patterns investigators can reconstruct the events of a crime and link victims/suspects to crime scenes.

# Presumptive Chemical Color Tests

## Phenolphthalein or Kastle-Meyer

A cotton swab is moistened with saline solution and rubbed against the suspected bloodstain, and then a drop of (ph) plus a drop of hydrogen peroxide is added to the swab. If the stain contains blood, the swab will turn pink-to-red within 15 sec.



# What do bloodstain patterns tell us about the crime?

- Distance
- Speed
- Direction
- Position of victim
- Position of perpetrator
- Direction in which weapon may have been swinging
- Direction in which blood may have trailed after impact.
- Whether blood was wiped or smeared
- Time elapsed
- Movement of blood between focal points
- Sequence of events

# Blood Stains on Victim's Jeans



Sections removed & initialed for testing



# Other Blood Patterns

- Not all bloodstains will fit neatly into either a dropped or impacted blood category. Some of the variations are:
  - Blood Pools
  - Contact-transfer bloodstain patterns
  - Wipe/swipe patterns
  - Blood imprint patterns

# Pool of blood



# Contact-transfer bloodstain pattern



# Wipe/swipe patterns



**Transfer from hair  
(hair-swipe) 2**

# Blood imprint patterns



# Neck incisions (scene)

<http://www.bloodspatter.com/BPATutorial.htm>

