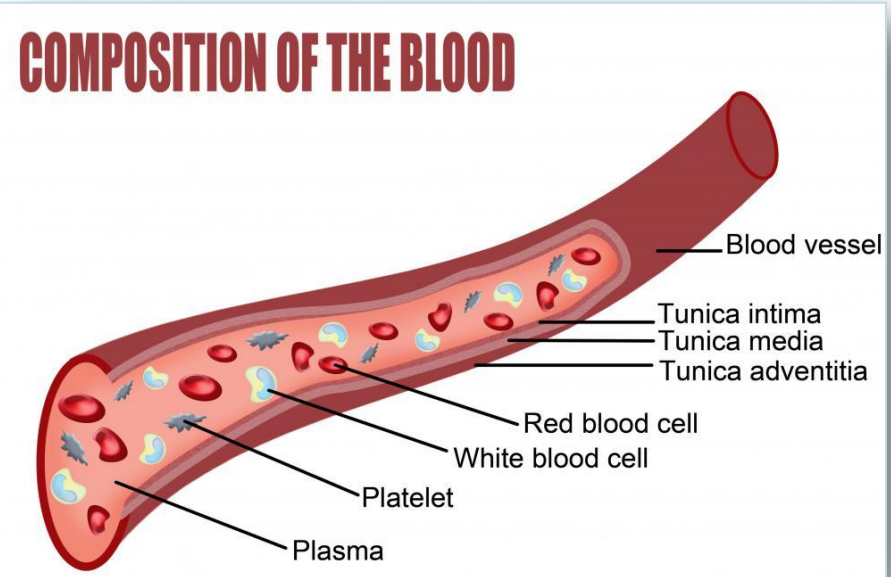
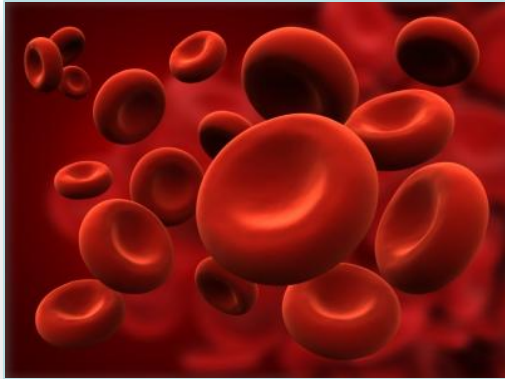


# Notes: Ch. 8

## Blood & Serology



- Why we need blood types  
<https://www.youtube.com/watch?v=xfZhb6lmxjk>
- Crash course true blood part 1  
<https://www.youtube.com/watch?v=HQWlcSp9SIs>
- Bozeman science blood  
<https://www.youtube.com/watch?v=KXTF7WehgM8>
- ABO simplified <http://study.com/academy/lesson/blood-types-abo-system-red-blood-cell-antigens-blood-groups.html>
- FF blood trails <https://www.youtube.com/watch?v=ZQVAutGZEdM>
- Catching killers  
<http://www.smithsonianchannel.com/shows/catching-killers/blood-spatter/1003122/3375551>
- <http://learn.genetics.utah.edu/content/inheritance/blood/>
- <http://www.nobelprize.org/educational/medicine/landsteiner/readmore.html>

# I. Forensic Serology

A. The study of blood, other body fluids, & its application to the law

- Blood
- Saliva
- Urine
- Semen



## B. Blood Clotting and Forensics

- 1. The clotting process begins 3-15 minutes from injury.
  - 1<sup>st</sup> forms dark, shiny, jelly-like mass
  - 2<sup>nd</sup> begins to contract and separate from serum.
- 2. How long ago did the victim begin bleeding?
  - A few minutes: Blood is still liquid
  - Less than an hour: Blood is shiny, gelatinous, in a pool.
  - Several hours: Blood has separated into clot and serum

# II. What is Blood?

**1. a liquid tissue**

**2. 7% of body weight**

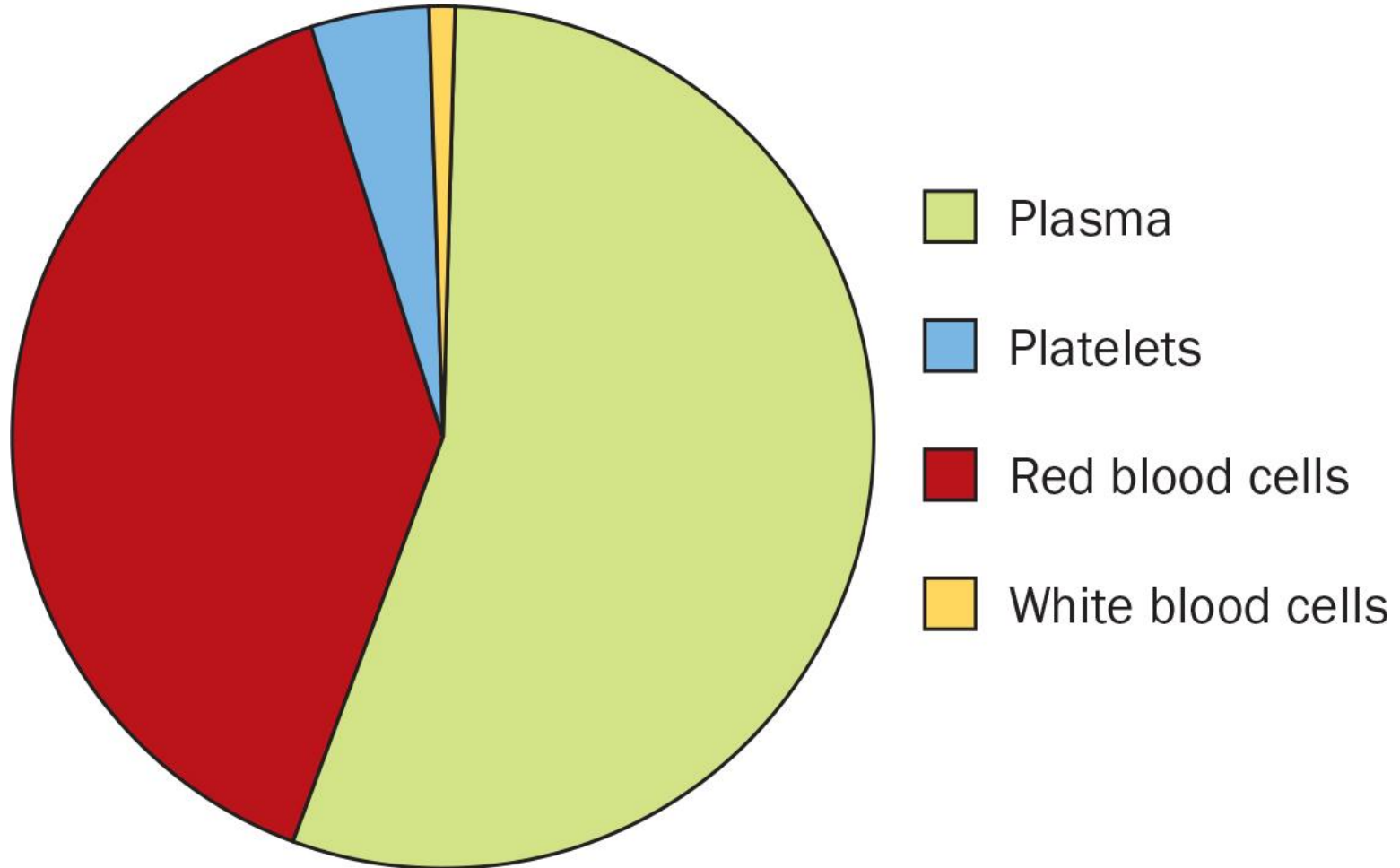
- **Females 4-5 liters (about 1-1.3 gallons)**
- **males have between 5-6 liters (1.3-1.6 gallons).**

**3. Blood = cells (45%) & plasma (55%)**

**a. Plasma – yellow- cells, gases ( $O_2$  &  $CO_2$ ) and molecules such as proteins, fats and carbohydrates (sugars).**

# Composition of Blood

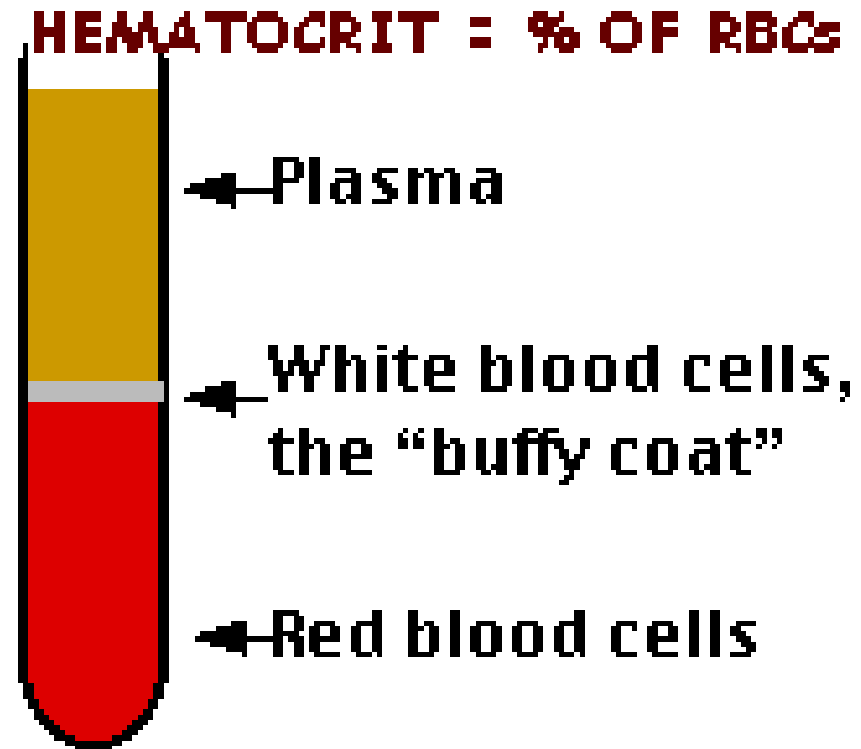
**Figure 8-2** Circle graph showing proportions of the components of blood.



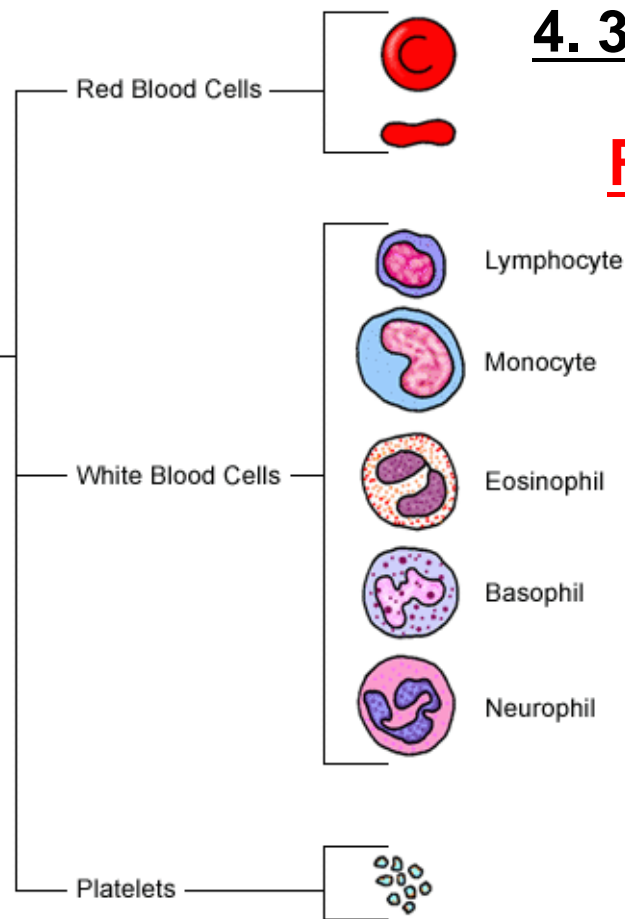
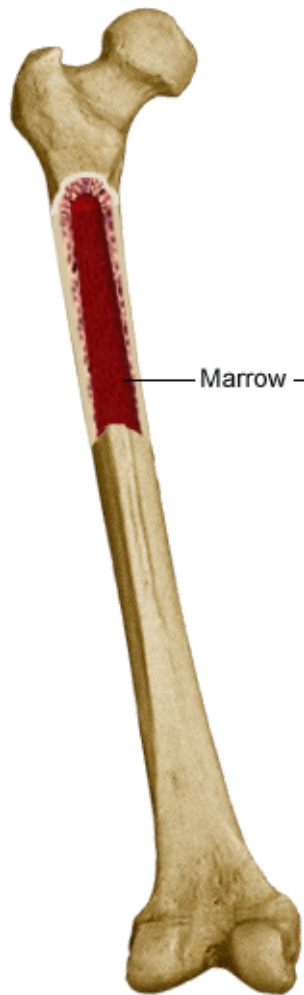
# Hematocrit

Hematocrit means the percentage of red blood cells in blood.

Scientists use a **centrifuge** to separate the parts of blood based upon density of the parts.



- A blood hematocrit is normally 45% cells and 55% plasma.



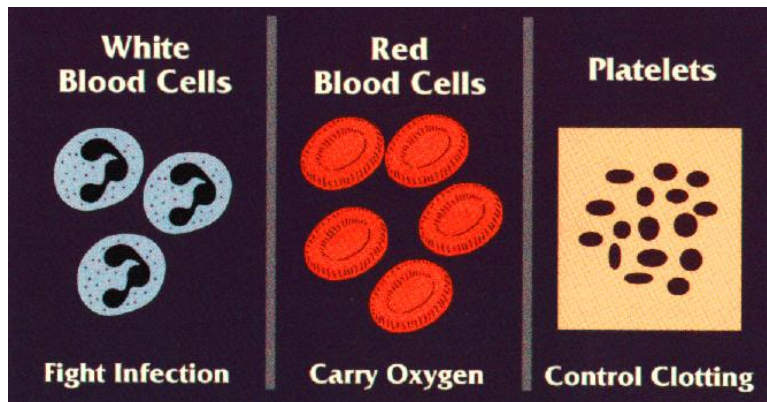
## 4. 3 kinds of cells :

**RBCs = erythrocytes.**

- Have **hemoglobin**
- **Iron**-containing protein
- Carry **oxygen /CO<sub>2</sub>**
- No **nucleus**

**WBCs = leukocytes**

- **immune** system cell
- Fight disease/ produce antibodies
- Contain **DNA**
- most common types = **lymphocytes** and **neutrophils**

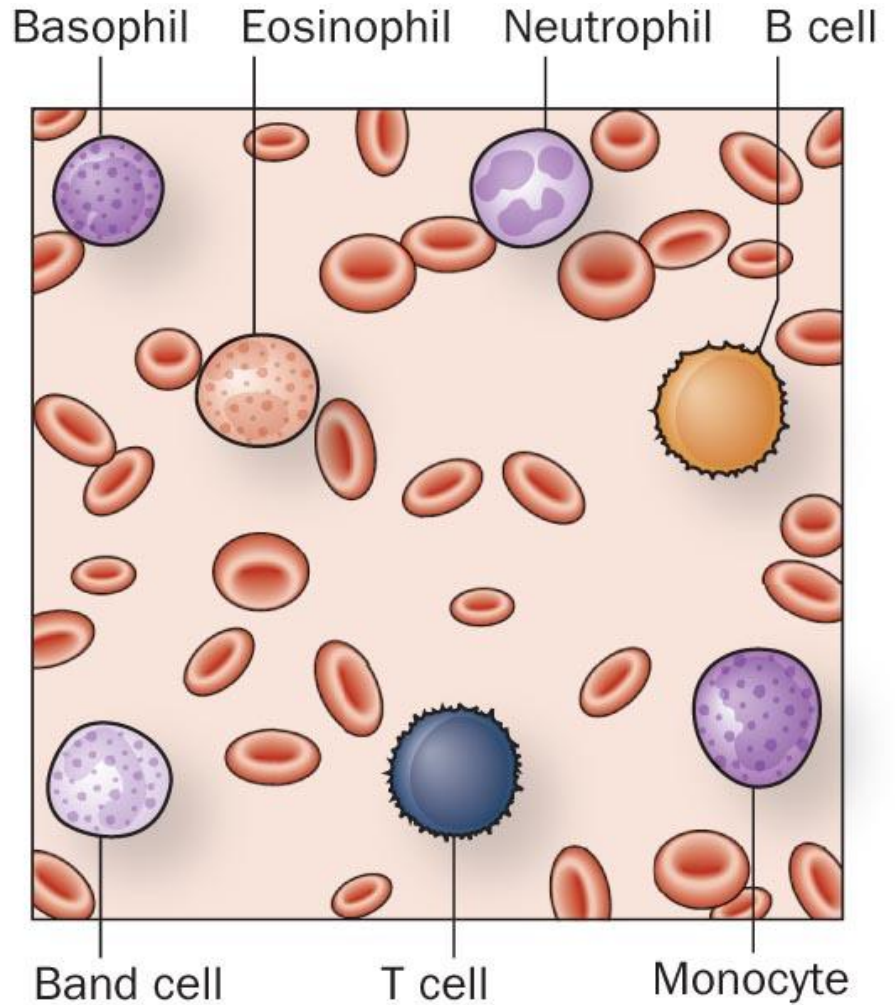


Platelets = **thrombocytes**

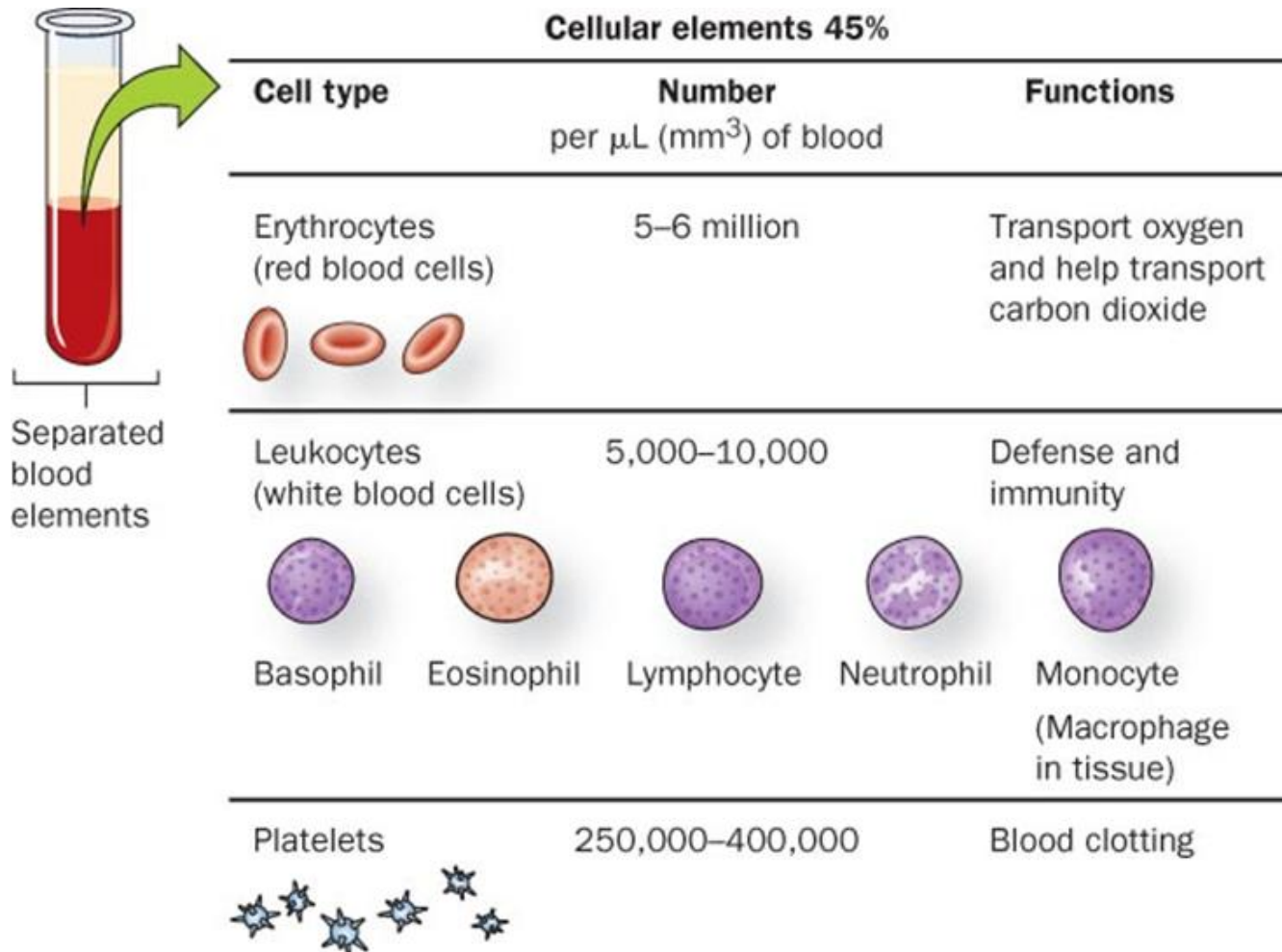
- small cell **fragments**
- assist in blood **clotting**

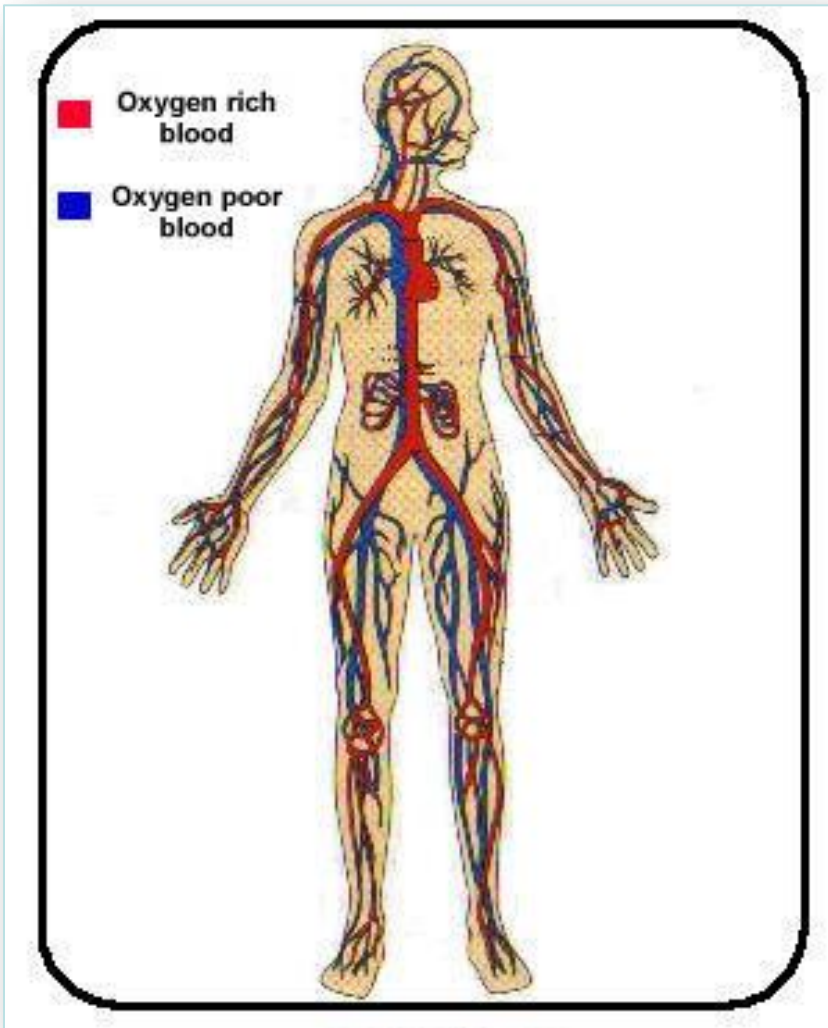


# Types of Blood Cells

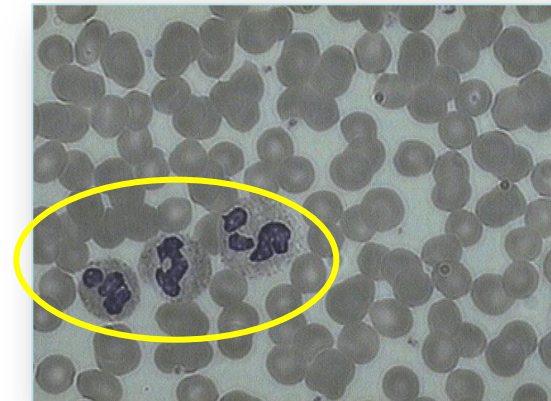


There are about one **billion** red blood cells in two to three drops of blood. For every **600** red blood cells, there are about **40** platelets and **one** white cell.





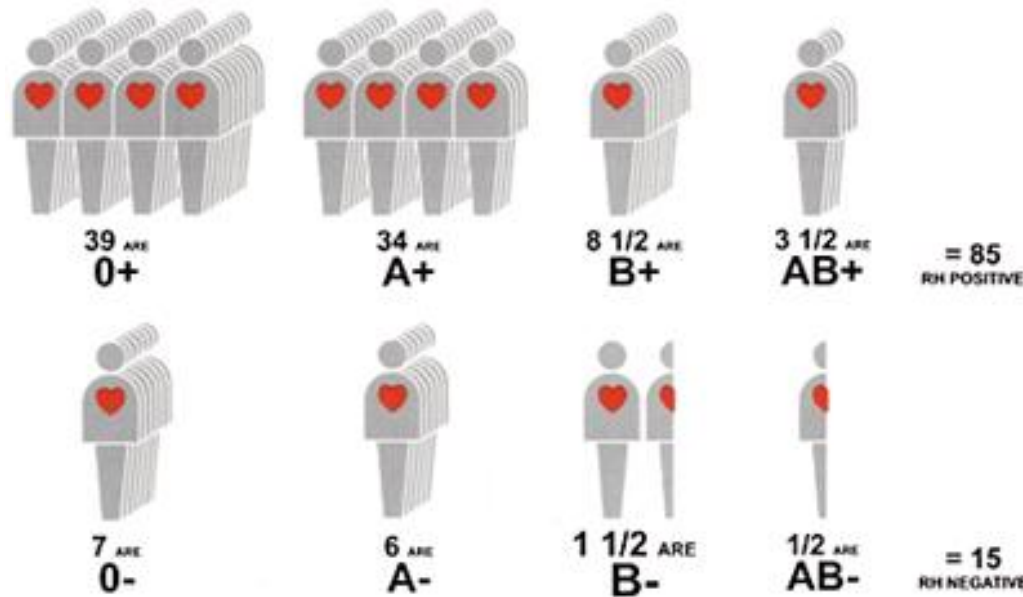
RBC's = No DNA, no nucleus



WBC's = DNA in nucleus

\*\*\*Blood is ***Individualized evidence*** (due to DNA)  
but class if just the type is known

Out of 100 Donors:



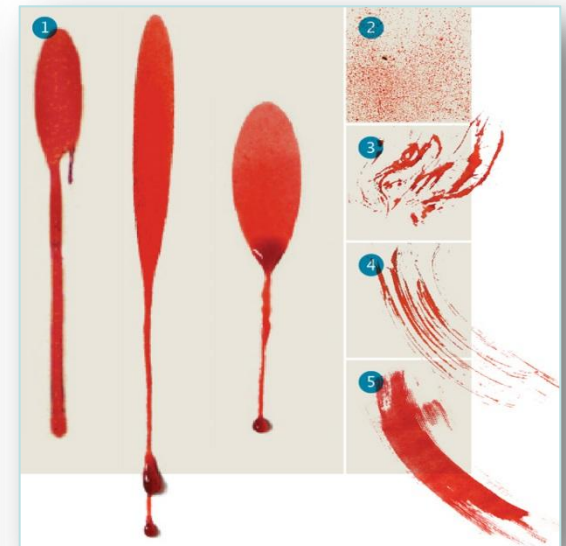
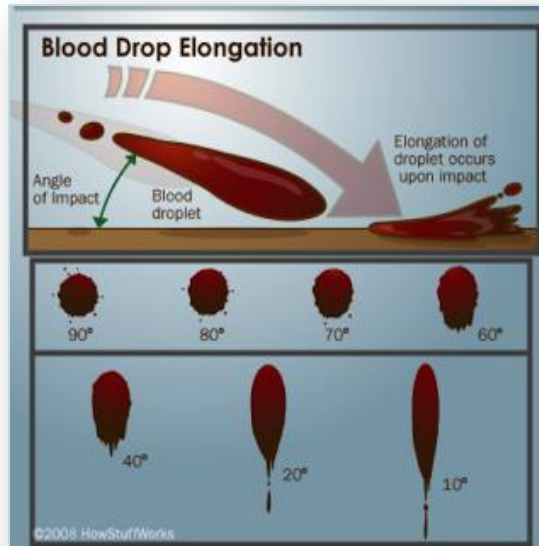
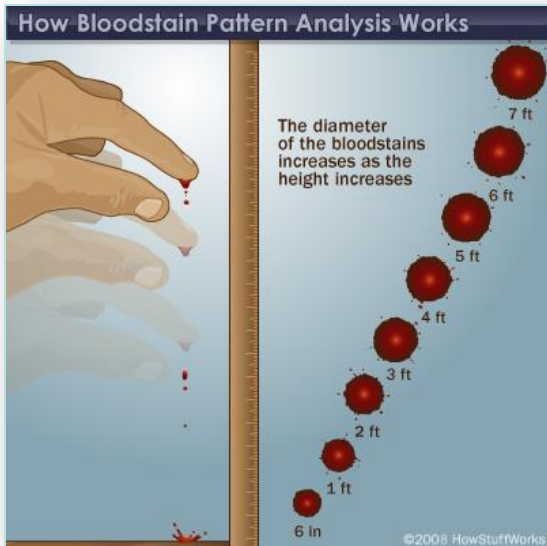
Blood typing is considered **class** evidence and is good to rule out suspects

DNA profiling from blood is considered **individual** evidence and can help pinpoint a suspect



# III. Crime Scene Investigator Tasks

- A. Is fluid *actually* blood?
- B. Is blood human or animal?
- C. Whose is it? Type, alcohol/drugs
- D. Perform *blood pattern analysis* to det. chain of events, type of injury, etc.



# IV. Is it blood? CSI Tests....

## A. Light Source

- high-intensity light or UV lights help find traces of *latent* blood and other bodily fluids.



“Reaction”

## B. Blood *Reagent* Tests

- based upon **hemoglobin** properties
- referred to as presumptive tests



# Presumptive Tests for Blood Determination

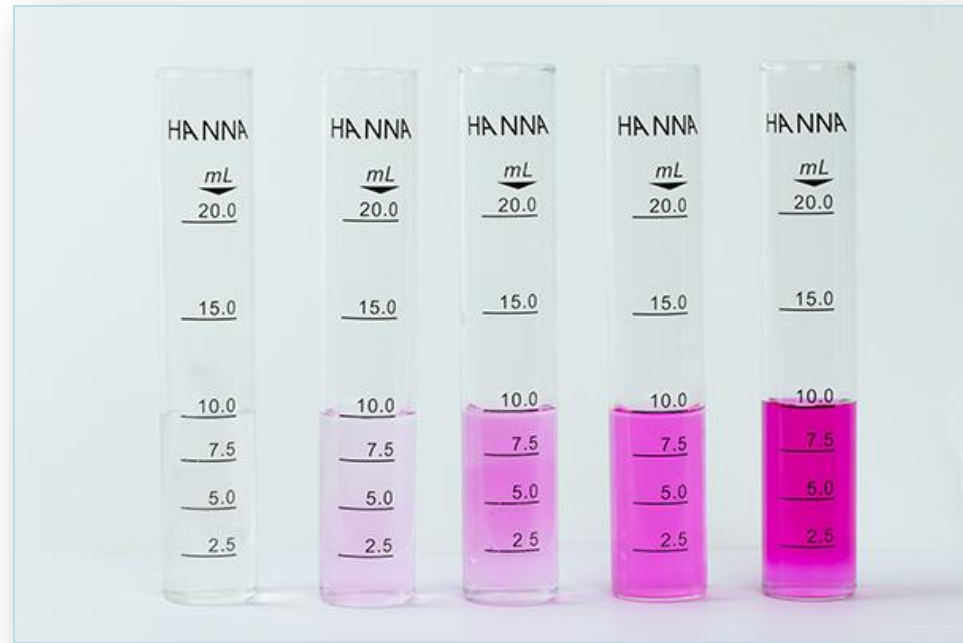
- 1. Kastle-Meyer test most common- phenolphthalein reacts with hemoglobin causes deep pink color
- 2. Hematest® tablet - reacts with the heme (iron) group in blood causing a blue-green color
- 3. Luminol test (most sensitive)- Solution sprayed and if “positive” blue glowing light is produced.
  - Same chemical used in “glowsticks”



Luminol  
15  
Reaction

# Phenolphthalein

- pink color



**HemaStix** is a strip that has been coated with tetramethylbenzidine (TMB) and **will produce a shade of green or green spots w/ the presence of hemoglobin.**





## 4. Fluorescein

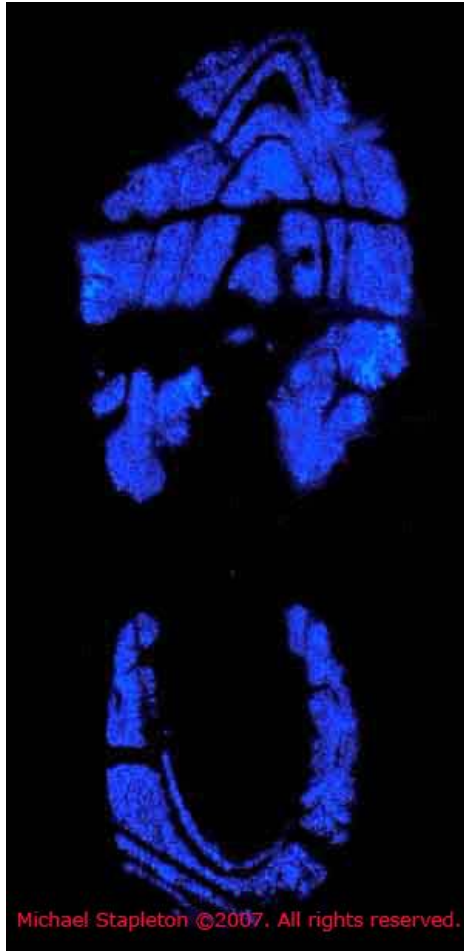
- capable of detecting latent (invisible) or old blood, similar to luminol. It is ideal for fine stains or smears found throughout a crime scene.
- a UV light & goggles are used to detect contaminated areas.
- appear greenish-white if blood is present. It may also react to many of the same things as luminol (copper & bleach).



**Fluorescein Reaction  
in UV Light**

**\*\*NOTE: all tests can react with other substances to produce a false positive**

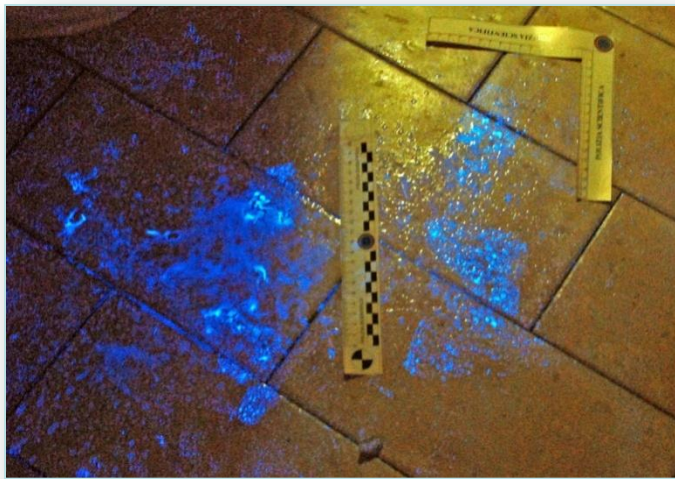
# What do you see with luminol?



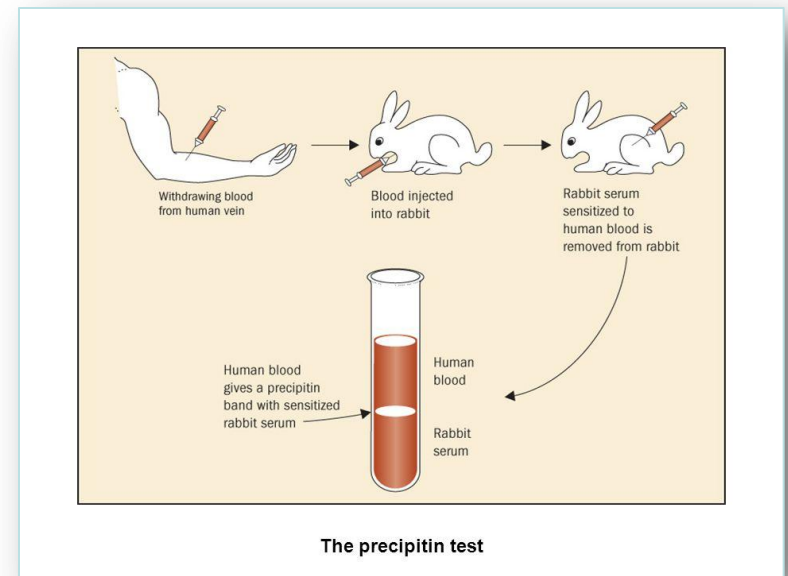
**It glows a bright blue in the dark, when it comes in contact with blood.**

# Bloody Footprints that were wiped





# Human vs. Animal Blood



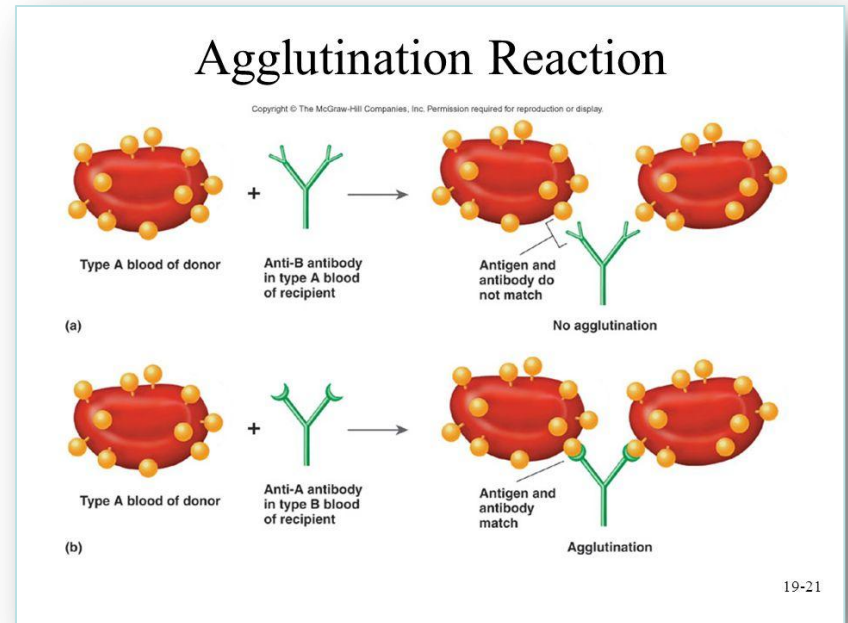
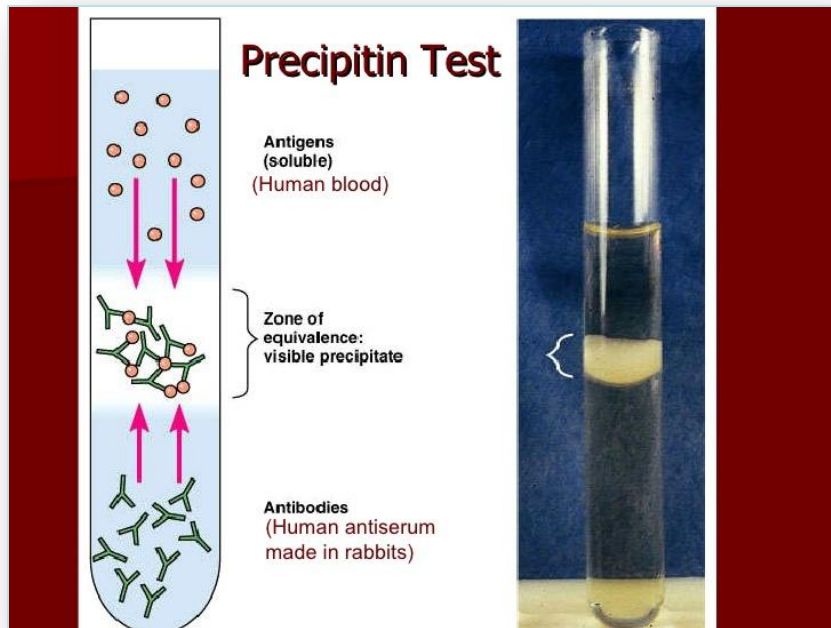
# V. It's blood. Human or Animal?

## A. Human

- Red
- Round cells, depressed donuts
- RBC's - no nucleus

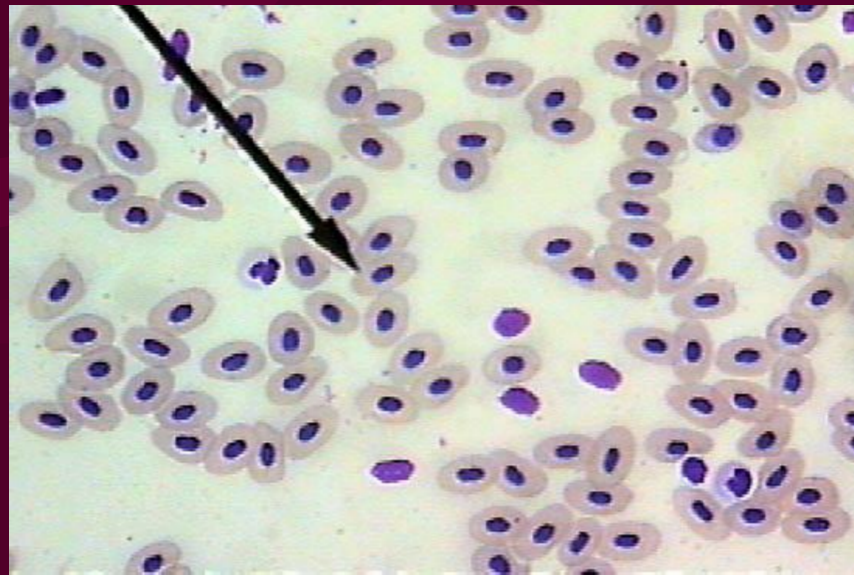
## B. Animals

- Poss. diff. color-  
green, blue, yellow, etc.
- diff. shapes, sizes
- Birds/reptiles-  
DO have nucleus



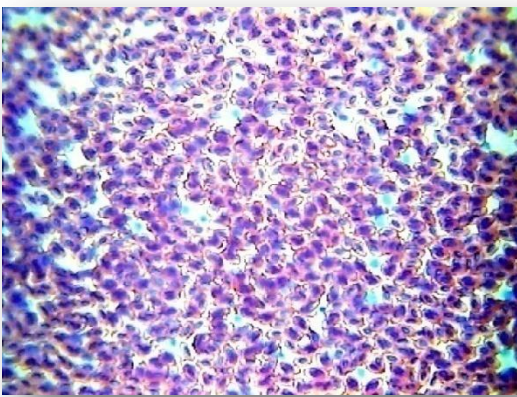
# Human vs Animal Blood

Animal Blood – red blood cells have larger nuclei

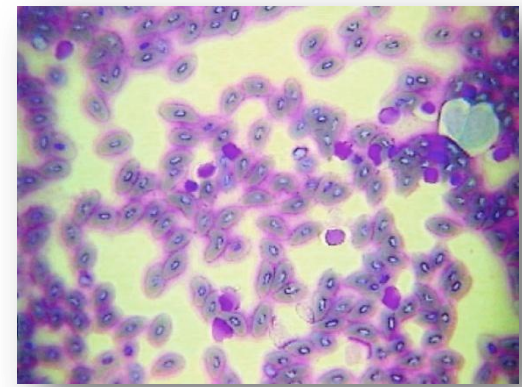


Frog Blood

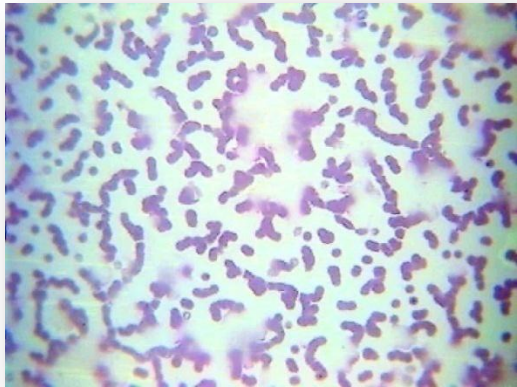
# Microscopic Views



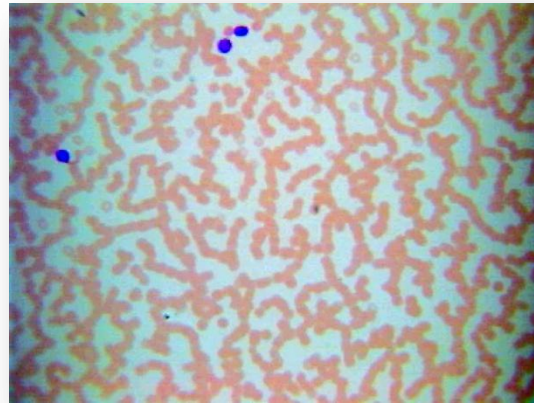
Bird Blood



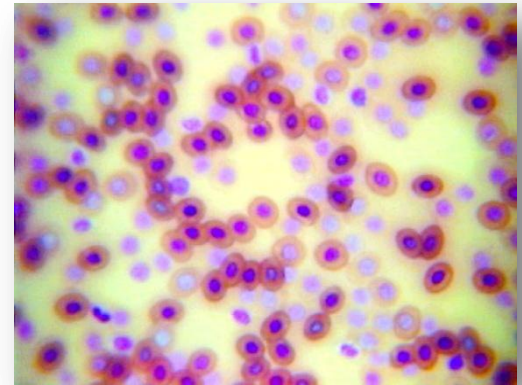
Fish Blood



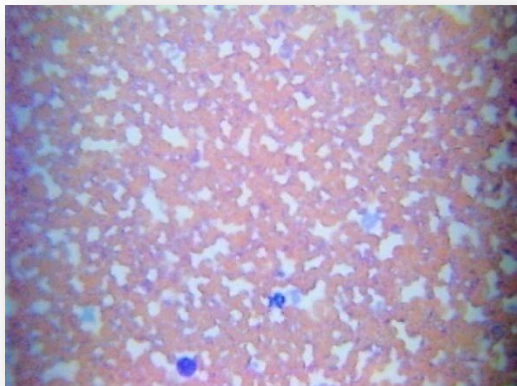
Cat Blood



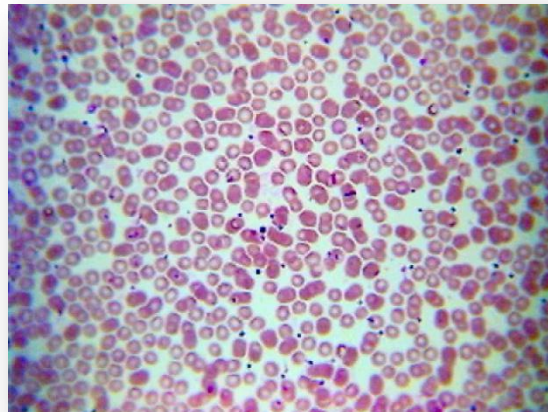
Horse Blood



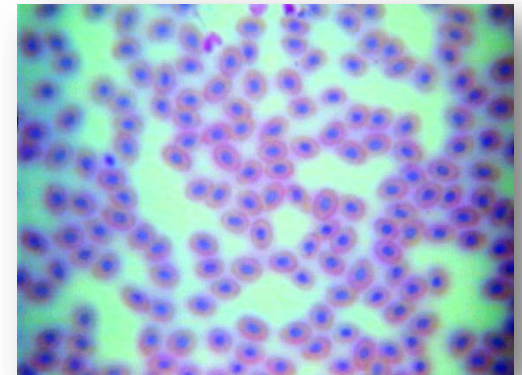
Frog Blood



Dog Blood



Human Blood

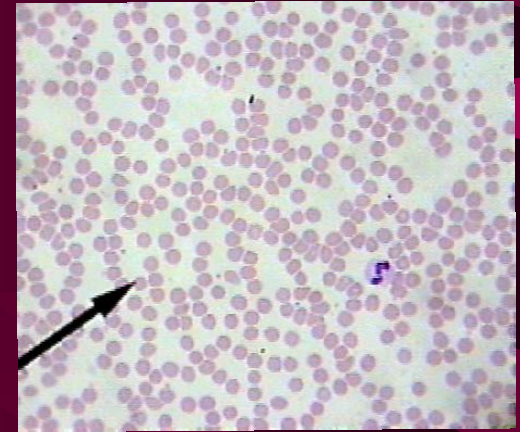


Snake Blood

# Human vs. Animal Blood (cont.)

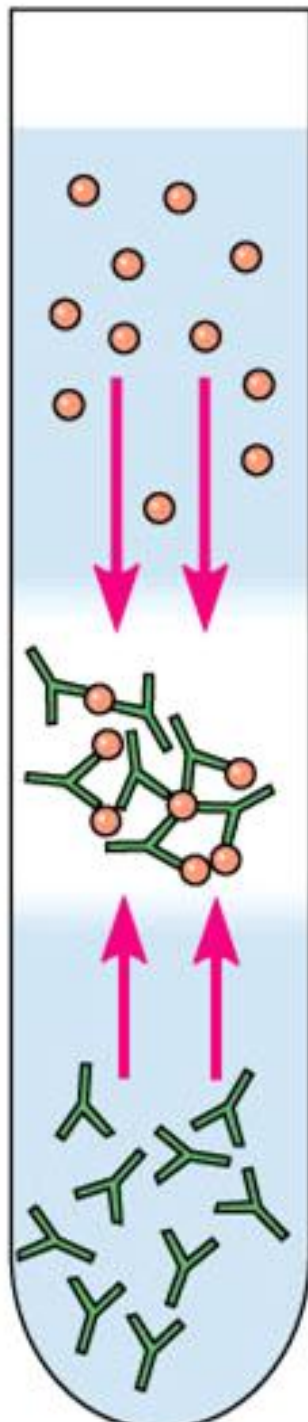
C. Precipitin test - very sensitive and requires only a small amount of blood.

- Human blood injected in rabbit
- Rabbit produces antibodies
- Antibodies extracted as antiserum
- Antiserum exposed to blood
- If it clumps, it's human blood.





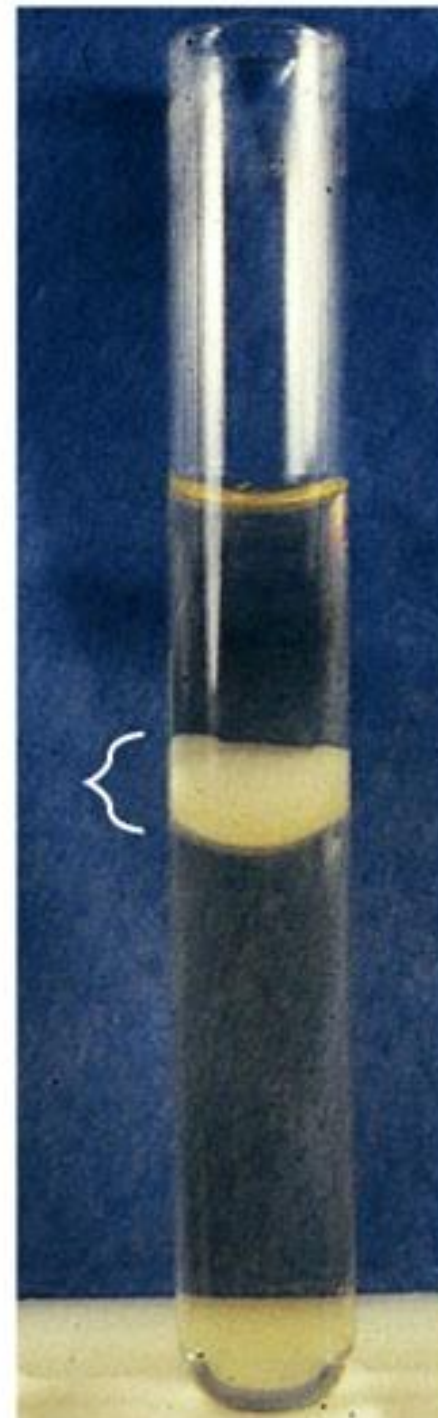
# Precipitin Test



**Antigens  
(soluble)**  
(Human blood)

**Zone of  
equivalence:  
visible precipitate**

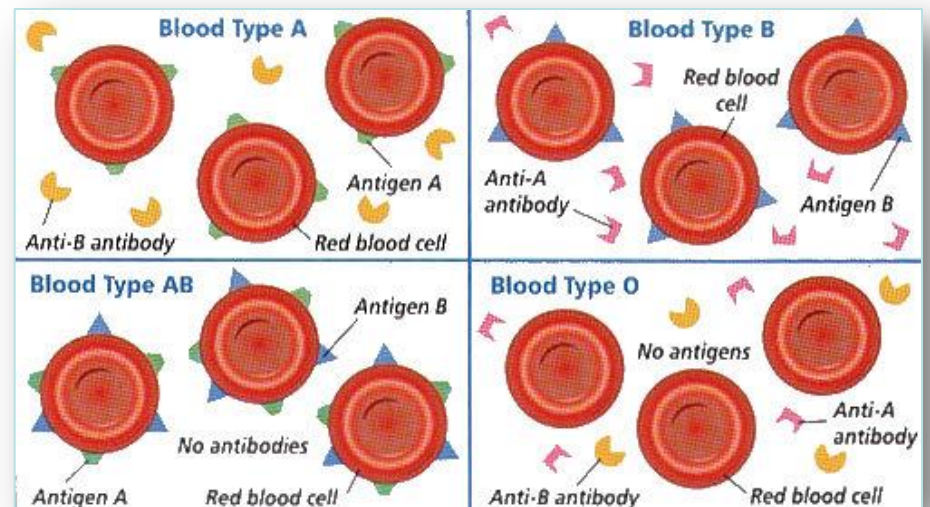
**Antibodies  
(Human antiserum  
made in rabbits)**



There are 4 major types of blood



# Blood Types

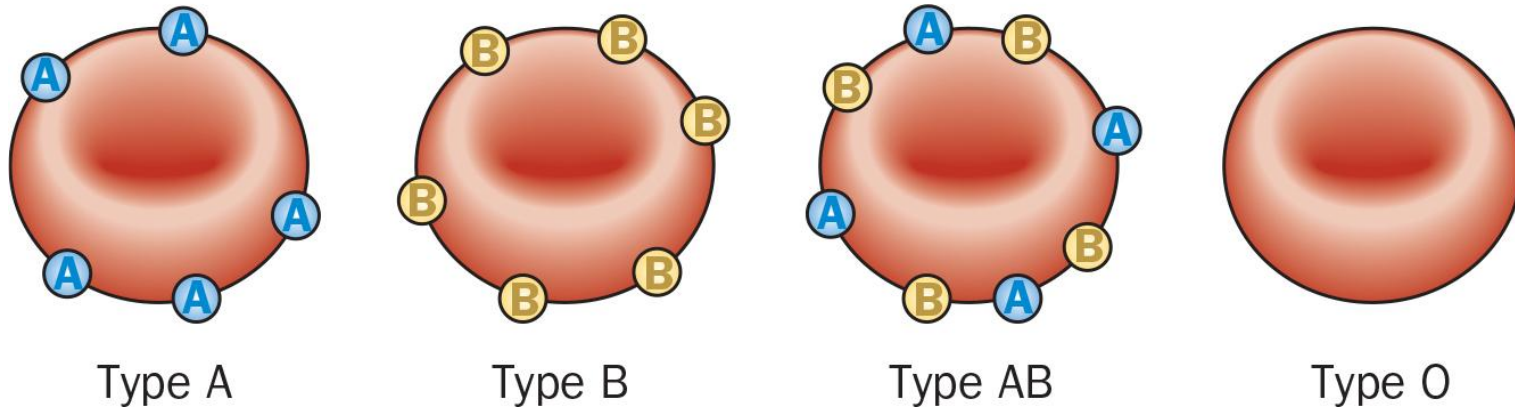


# VI. Blood Terminology

A. Antigen – a protein that can stimulate the body to make antibodies.

- Certain antigens on rbc account for blood type.

**Figure 8-5** *A diagrammatic representation of the antigens for the human ABO blood types.*

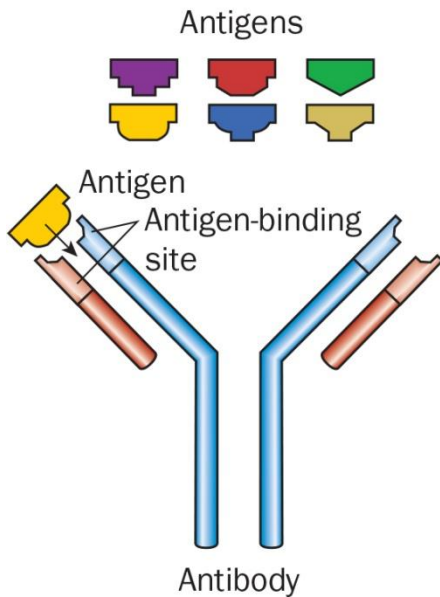


© Cengage Learning®

# Blood Terminology

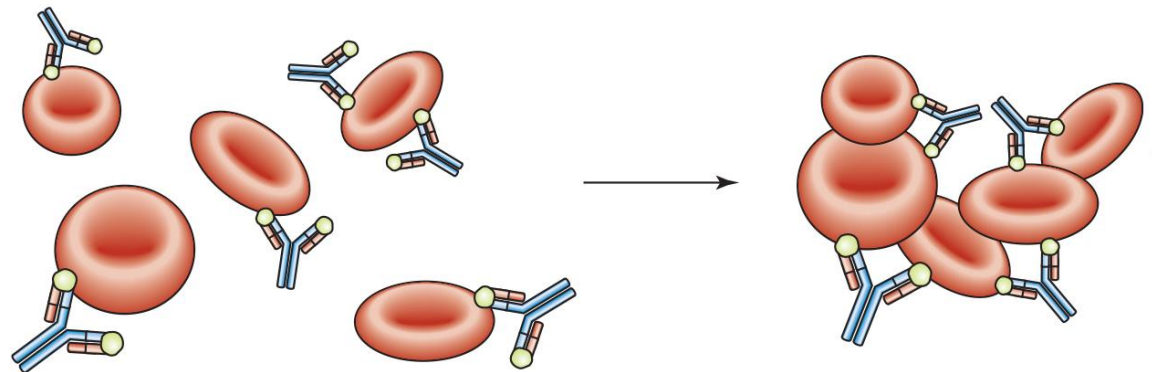
- B. Antibody – a substance that reacts with an antigen
- C. Agglutination – clumping of red blood cells; results if blood types with different antigens are mixed.

**Figure 8-8** *The shape of the antigen fits the binding site on the antibody.*



© Cengage Learning®

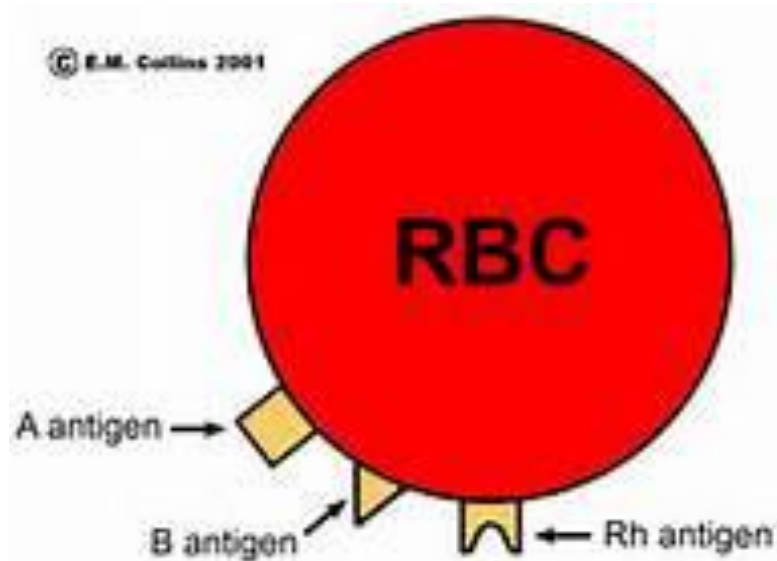
**Figure 8-9** *An antibody reaction to surface antigens on red blood cells causes agglutination, or clumping, of the cells. Agglutination can be fatal.*



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# VII. Blood Types

- A. Blood type established in vitro. (womb)
1. inherit one gene from mom and one from dad
  2. genes cause presence or absence of proteins (called AGGLUTINOGENS) on the surface of red blood cells.



- 3. 1901 - Karl Landsteiner discovered three blood types based on antigens on red blood cells. (A, B, O)
- 4. 1940 Landsteiner reported the discovery of the Rh factor by studying the blood of the Rhesus monkey.
  - 82% of Caucasians, 93% of Hispanic and African Americans and 99% of all Asians are Rh positive.

# B. What are blood types?

1. There are three genes for blood type: A, B, and O.
2. Since we have 3 genes, 6 possible combo's →



## Blood Types

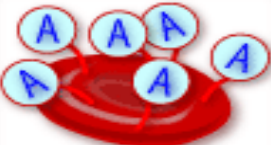






AA or AO = Type A

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

# C. Blood Groups

\*\* You can memorize this table or learn how the antigens react with the antibodies. I suggest the second option!!!

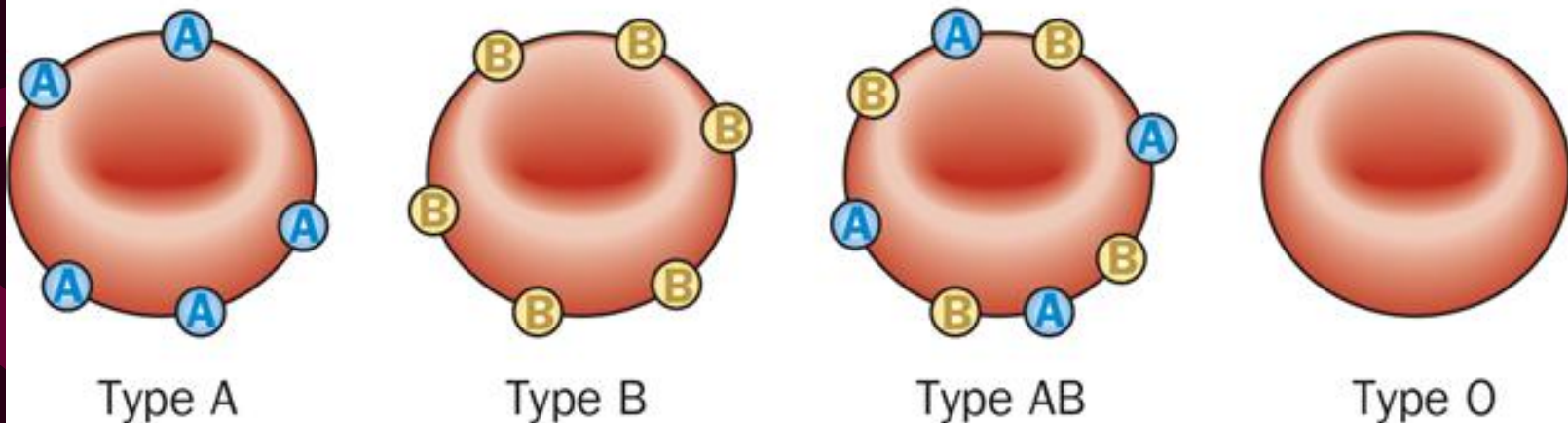
<b>Type</b>	<b>Antigen</b>	<b>Antibody</b> (will agglutinate with)	<b>Can Give Blood To</b>	<b>Can Get Blood From</b>
A	A	B	A, AB	O, A
B	B	A	B, AB	O, B
AB	A and B	Neither A nor B	AB	A, B, O, AB
O	Neither A nor B	A and B	A, B, O, AB	O



# D. A and B Antigens

- 1. The percentage of the US population with each of the four ABO blood types:
  - Type O (43%) -- Type B (12%)
  - Type A (42%) -- Type AB (3%)

**Figure 8-5** A diagrammatic representation of the antigens for the human ABO blood types.



# Blood Types and the Population

O positive is the most common blood type. Not all ethnic groups have the same mix of these blood types. Hispanic people, for example, have a relatively high number of O's, while Asian people have a relatively high number of B's. The mix of the different blood types in the U.S. population is:

	Caucasians	African-American	Hispanic	Asian
<b>O +</b>	37%	47%	53%	39%
<b>O -</b>	8%	4%	4%	1%
<b>A +</b>	33%	24%	29%	27%
<b>A -</b>	7%	2%	2%	0.5%
<b>B +</b>	9%	18%	9%	25%
<b>B -</b>	2%	1%	1%	0.4%
<b>AB +</b>	3%	4%	2%	7%
<b>AB -</b>	1%	0.3%	0.2%	0.1%

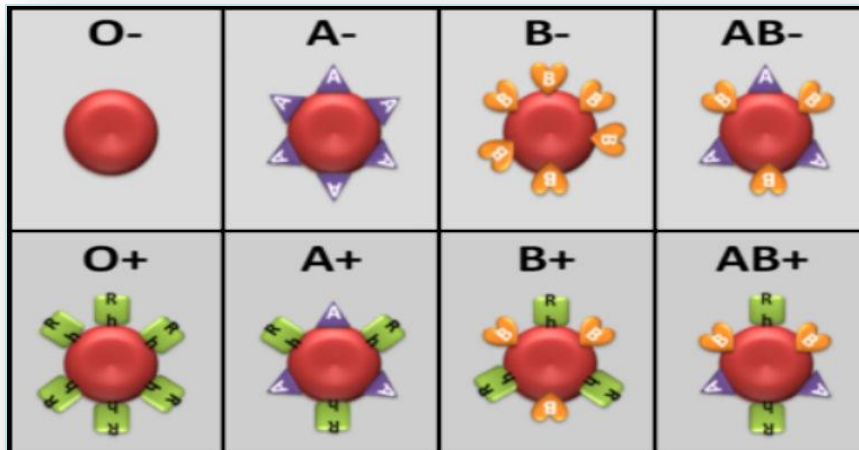
# How common is your blood type?

<b>TYPE</b>	<b>DISTRIBUTION</b>	<b>RATIOS</b>	
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%	3.9%
AB -	1 person in 167	0.7%	

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

# E. Rh Factors

- 1. Eighty-five percent of the human population has a protein called Rh factor on their red blood cells.
- 2. Found from studying Rhesus monkey.
- 3. The presence of a specific protein, or lack of it, is referred to as the Rh (for **Rhesus**) factor.
  - Yes protein = Rh **positive** (Rh<sup>+</sup>)
  - No protein = Rh **negative** (Rh<sup>-</sup>).



**A<sup>+</sup> A<sup>-</sup>**  
**B<sup>+</sup> B<sup>-</sup>**  
**AB<sup>+</sup> AB<sup>-</sup>**  
**O<sup>+</sup> O<sup>-</sup>**

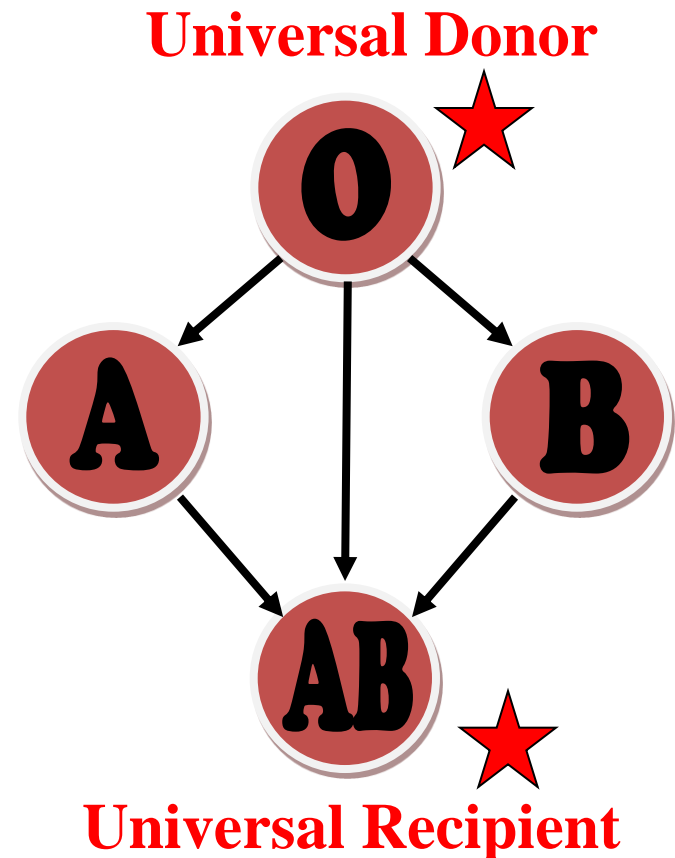
# F. Blood Transfusions (donations)

1. **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.

- 2. Who can give you blood?
- Type 0 Universal Donors, can **GIVE** blood to any blood type.
- **TYPE AB** Universal Recipients, can **RECEIVE** any blood type.

**Rh<sup>+</sup> → Can receive + or -**

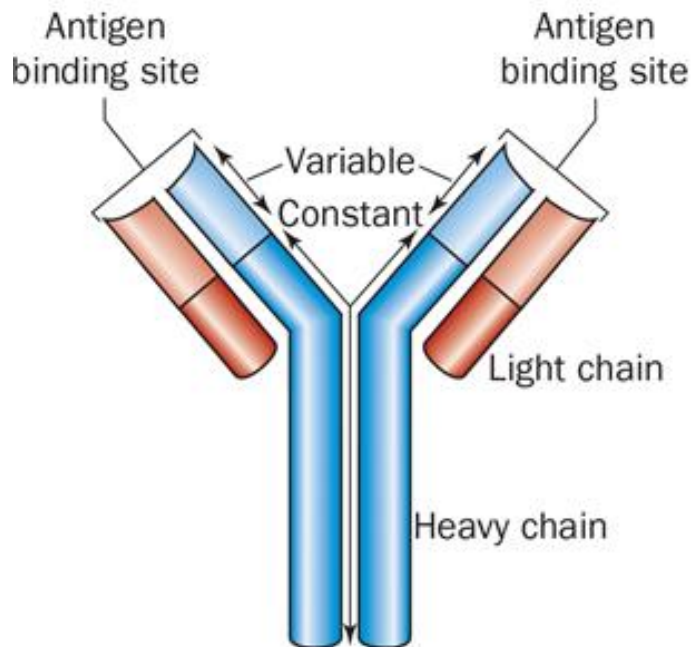
**Rh<sup>-</sup> → Can only receive -**



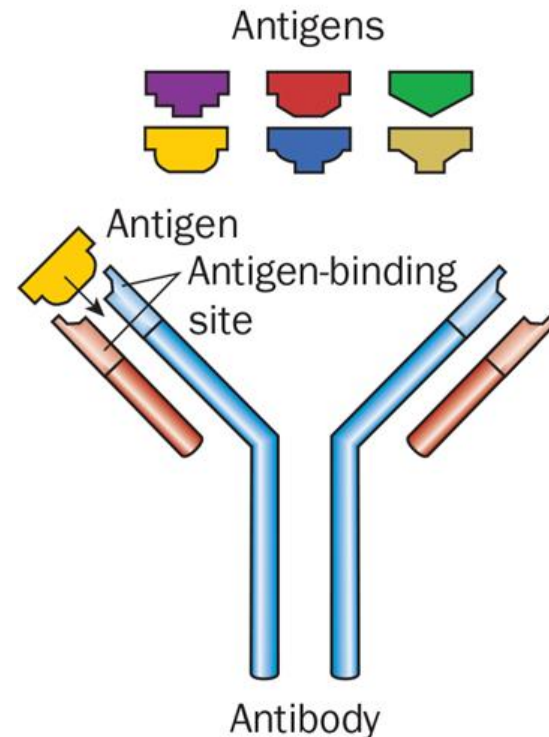
# 3. Antigen-Antibody Response

- a. occurs when white blood cells recognize a substance as foreign and try to destroy it.

**Figure 8-7** *The general structure of an antibody.*



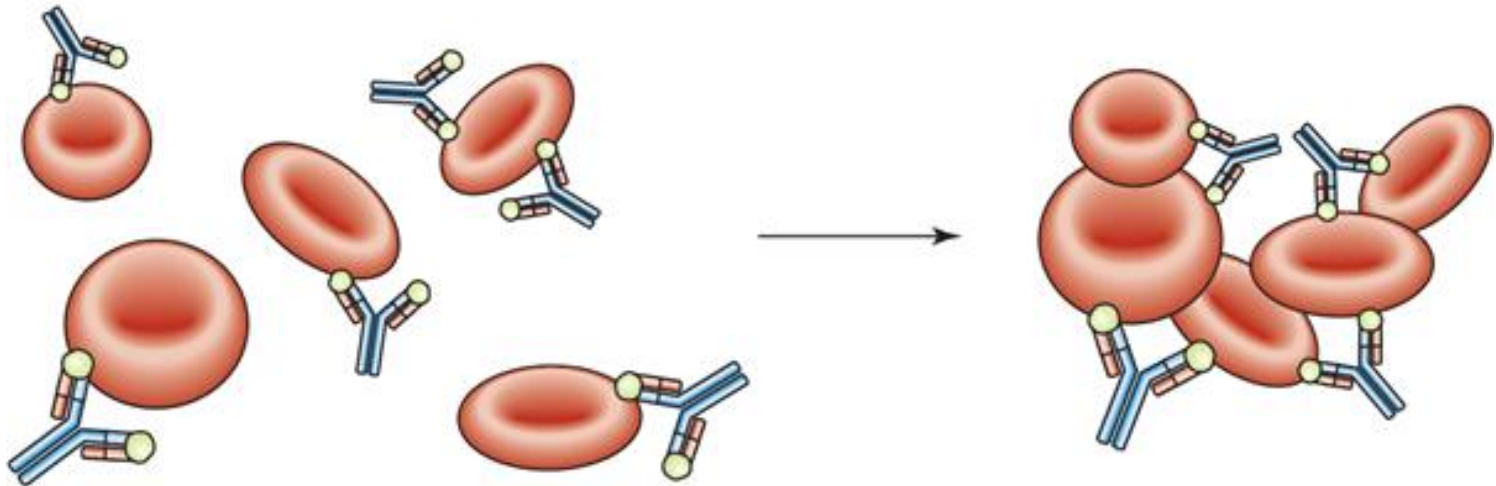
**Figure 8-8** *The shape of the antigen fits the binding site on the antibody.*



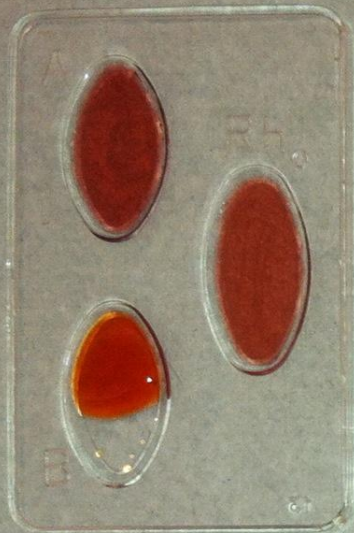
# 4. Agglutination

- a. If clumping occurs within the circulatory system blood could cease to flow.
- b. Without blood circulation, a person dies.

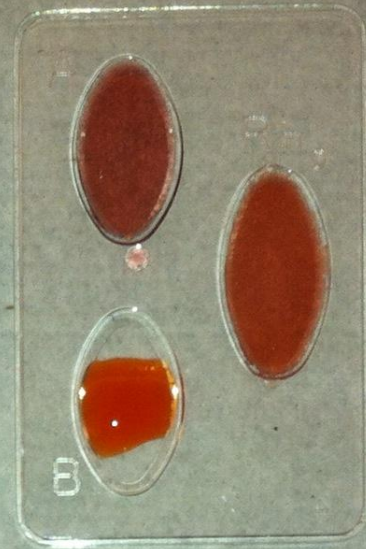
**Figure 8-9** *An antibody reaction to surface antigens on red blood cells causes agglutination, or clumping, of the cells. Agglutination can be fatal.*



A+ C.S.

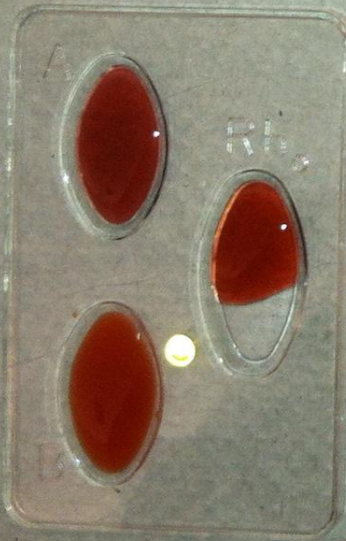


V B-

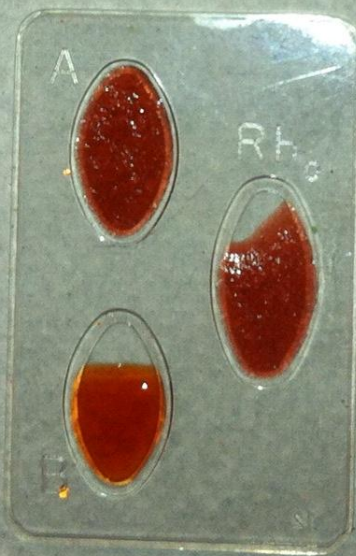


S#1  
AB+

Ward's Whodunnit  
LAB



#2  
B-



#3  
A+



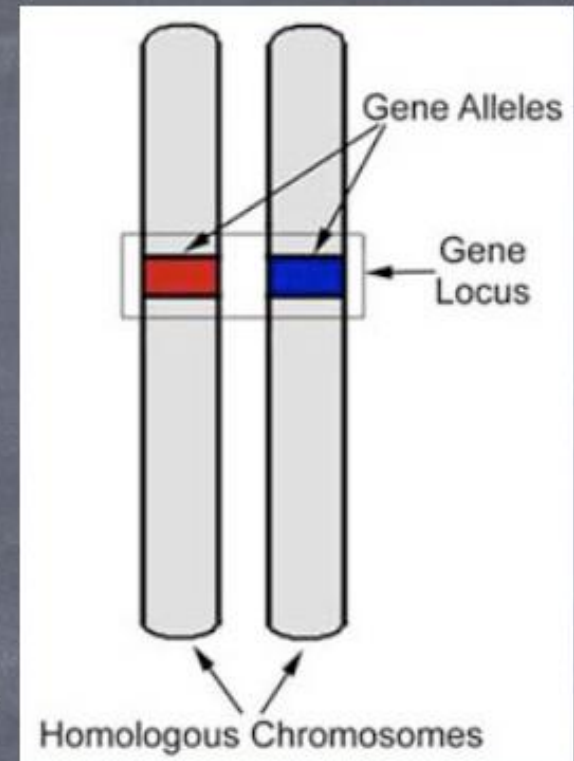
O-  
#4



## D. Inheriting your blood type

### 1. Our Genetic Material

- ▶ chromosomes are our hereditary information (DNA)
- ▶ genes are segments of DNA, which code for genetic traits (found at specific loci on the chromosome)
- ▶ alleles are the different types of genes that code for a particular trait
- ▶ a person inherits two alleles for ONE trait, that is one allele from her mother and one allele from her father



- Genotype: describes the allelic pair combination
- Phenotype: describe the trait/characteristic expressed

# Genetic Blood Typing (Genotypes)

	Mother			
		A	B	O
Father	A	AA	AB	AO
	B	AB	BB	BO
	O	AO	BO	OO

# Transmission of our traits

<b>Allele Combinations</b>	<b>Blood Type (phenotype)</b>
<b>AA + AO</b>	<b>A</b>
<b>BB +BO</b>	<b>B</b>
<b>AB</b>	<b>AB</b>
<b>OO</b>	<b>OO</b>



# VIII. Bloodstain Pattern Analysis

# A. Blood Splatter

- 1. 1939—splatter patterns first analyzed
- 2. Blood may splatter when a wound is inflicted
- 3. Blood splatter pattern—a grouping of blood stains
- 4. Patterns help to reconstruct the events surrounding a shooting, stabbing, or beating

## B. Analysis of a spatter pattern can help to determine:

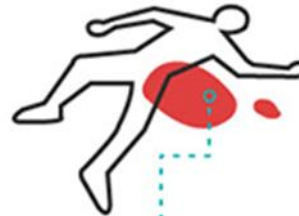
1. direction blood traveled
2. angle of impact
3. point of origin of the blood
4. velocity of the blood
5. manner of death



Date and time of crime



Type and velocity of weapon



Movements/position of those involved



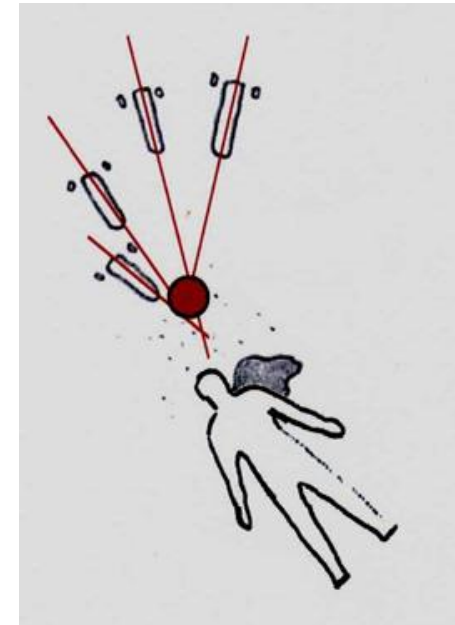
If the assailant was left or right handed



Types of injuries dealt



Whether death was immediate



Bloodstain pattern analysis can also help one evaluate the credibility of statements provided by a witness, a victim, or a suspect.

# HOW BLOOD FALLS AND SPATTERS

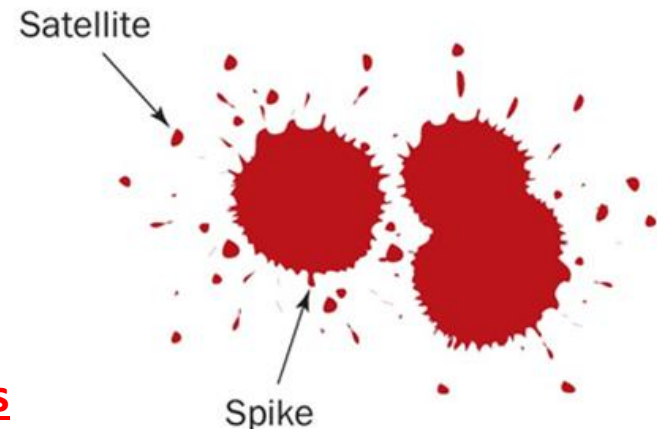
## C. Cohesion

1. Blood **sticks** together as it falls maintaining a **round** shape.
2. Blood also resists flattening out when it falls on a flat surface. **Cohesion** and surface tension help it to maintain a **curved** shape.



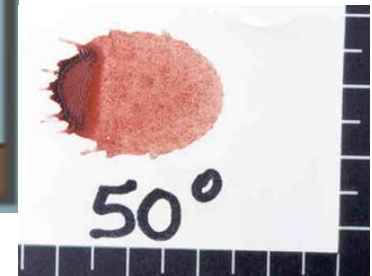
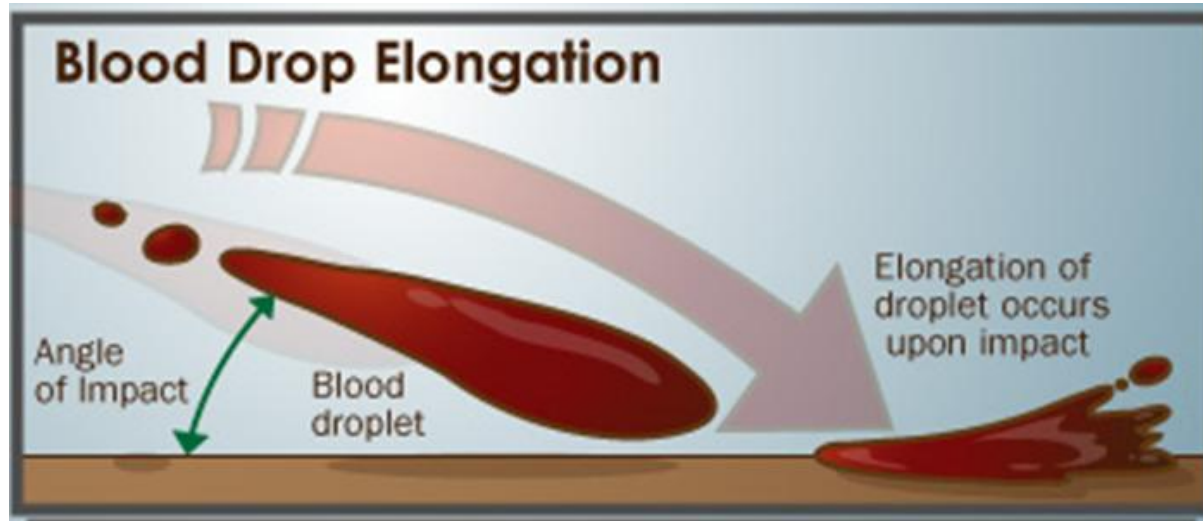
## D. The shape of an individual drop of blood can provide important clues

- 1. When blood falls from a **height**, or at a high **velocity**, it forms **satellite** droplets, small secondary droplets around the main drop (parent drop)
- 2. When blood falls onto a less-than-smooth surface, the edges may have **spikes** or extensions





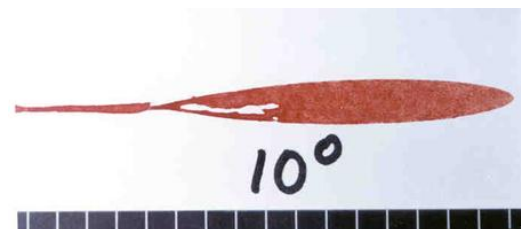
E. An elongated blood drop indicates blood was traveling from a different direction when it landed.

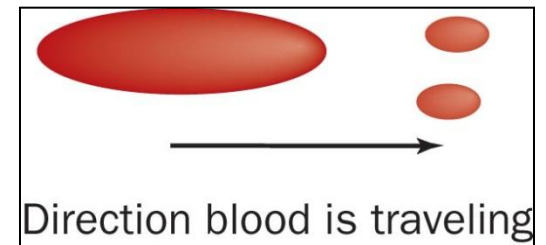
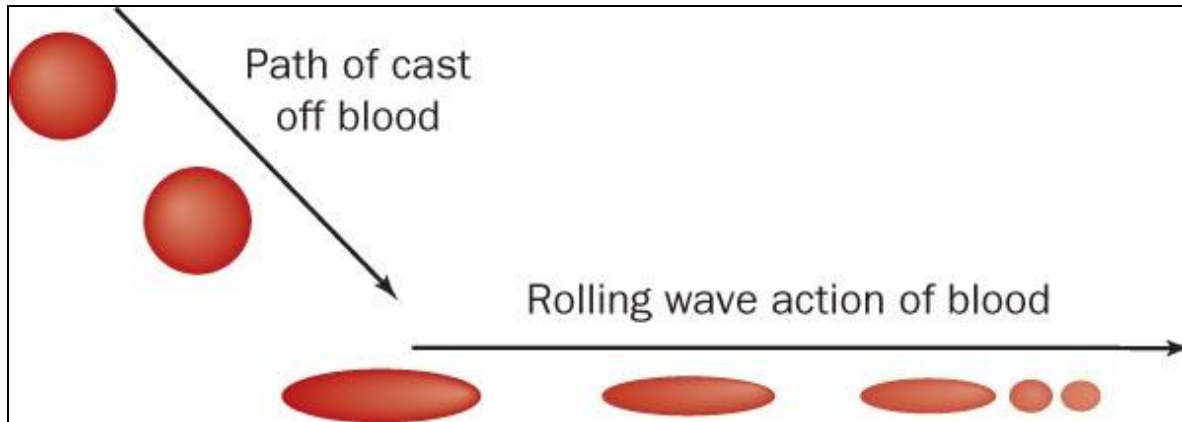


1. The point of impact may appear darker and wider with a tail pointing in the direction of the blood's movement.

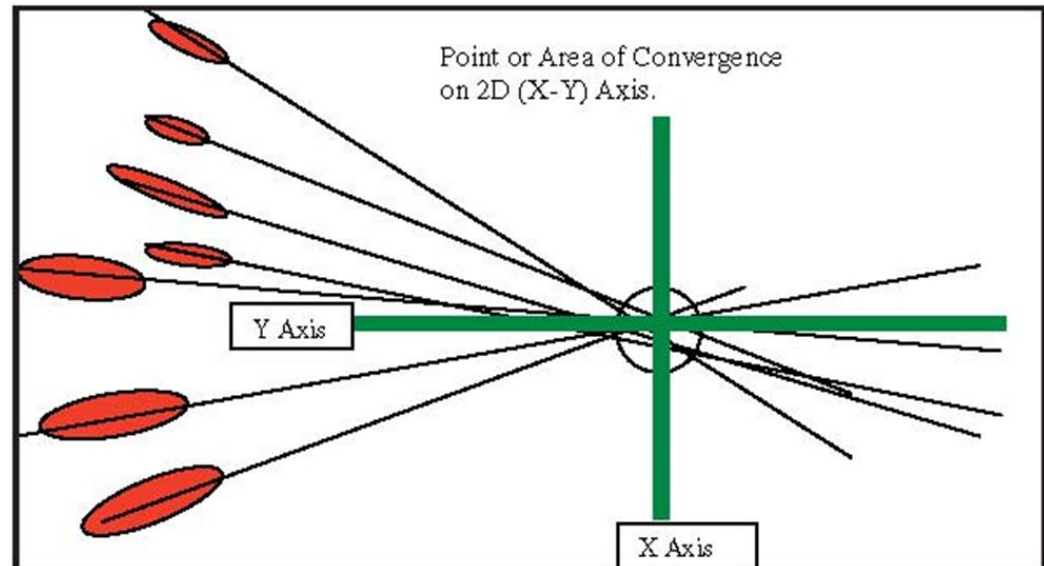
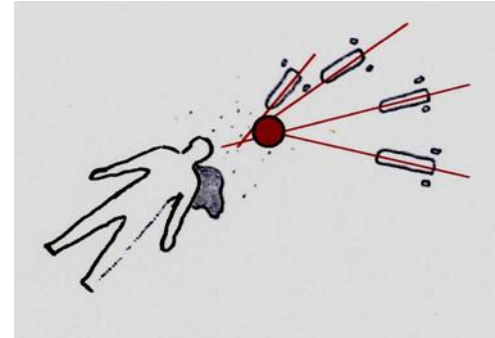
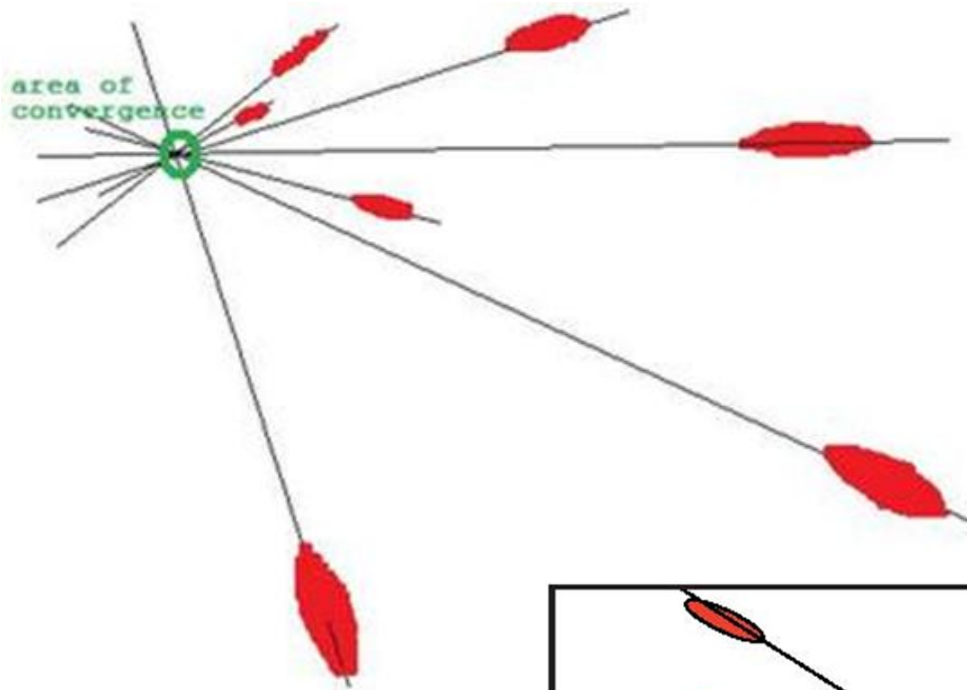


a. Smaller, secondary droplets may break off and will land in front of the moving droplet of blood, allowing scientists to determine direction of spatter.





F. When there are two or more blood spatters a scientist can draw **LINES OF CONVERGENCE** that can pinpoint the location of the blood source.



# G. Blood Splatter Analysis —Six Patterns

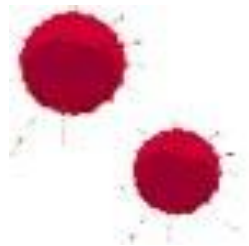


Describe each of these:

- a) Passive drops
- b) Arterial gushes
- c) Splashes
- d) Smears
- e) Trails
- f) Pools

# DIFFERENT KINDS OF BLOOD SPATTER

## Passive drops



## 6. Arterial gushes



## Splashes



1. Passive fall (90° angle to floor)– circular drops w/secondary satellites

2. Splashes help show position of victim

3. Smears – bleeding victim touching walls or furniture

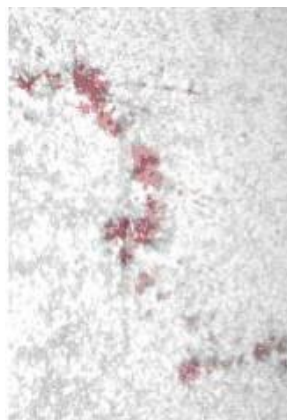
4. Blood Trails – victim moving from one place to another

5. Blood Pools – victim bleeds heavily

## Smears



## Trails



## Pools



# SMEARS

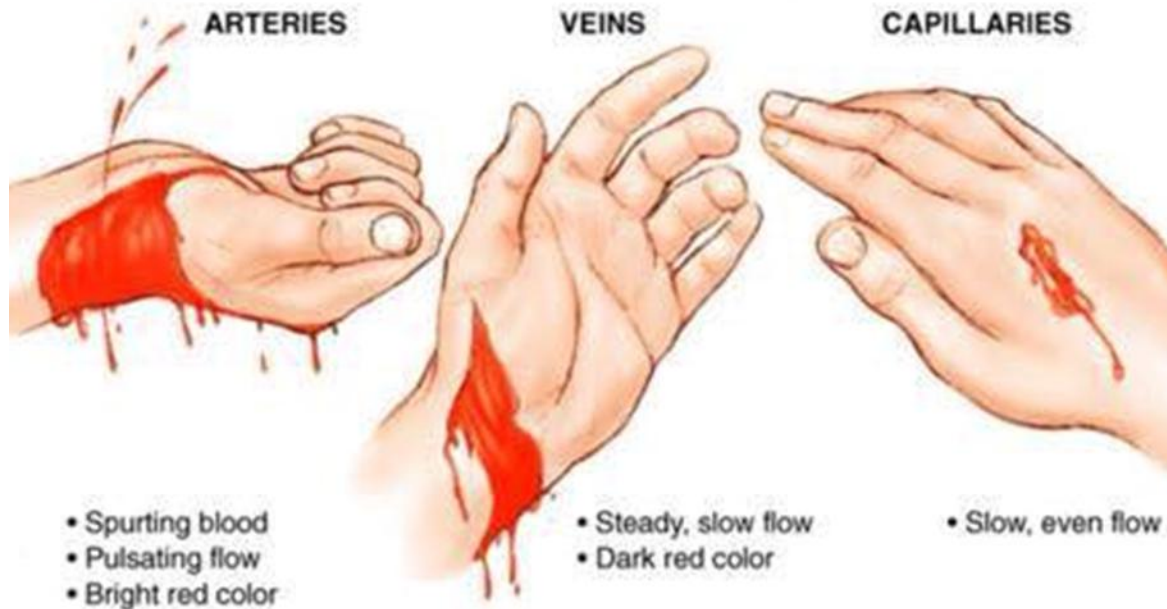
1. Smear patterns from a large volume of blood, at least 0.5 ml, are often distorted so much that further classification is not possible.
2. However, Transfer Patterns occur when a wet bloody surface contacts a second unstained surface creating recognizable mirror image or at least a recognizable portion of the original surface.
  - a. Swipe Pattern - the transfer of blood onto a surface not already contaminated with blood. One side is usually feathered which indicates the direction of travel.
    - i. One common pattern at scenes is a hair swipe - a long thin fine line transfer.
  - b. Wipe Pattern - created when an object moves through blood that has not completely dried and moves, removes, or otherwise alters it.



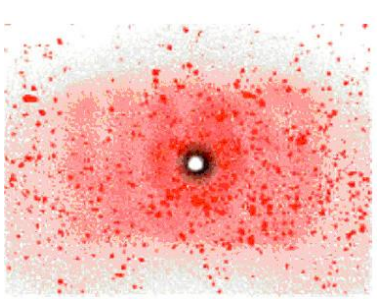


# GUSHES

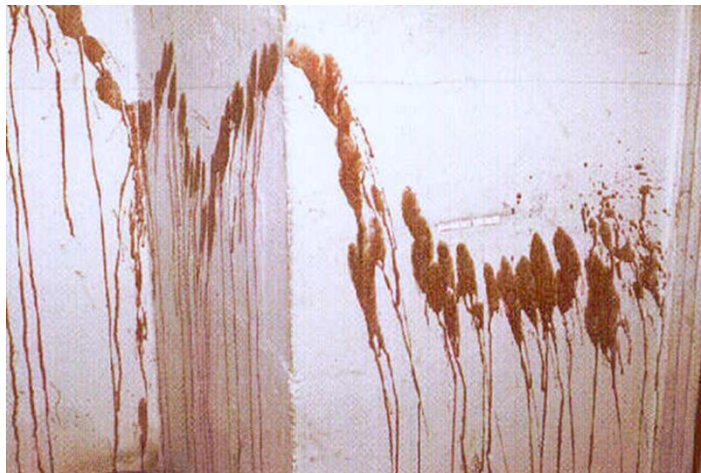
1. Arterial spurting usually occurs when an artery is damaged and the blood spurts or gushes from the wound in large volume pulses. It continues spurting as long as the heart continues beating.

2. Large drops striking a vertical surface decelerate from air resistance and produce a pattern without spines. The drops strike the surface and then characteristically drip or run downward due to their large volume.



# H. Speed and Velocity also impact blood spatter.

	High Velocity	Medium Velocity	Low Velocity
Example:	<u>Gunshot wound</u>	<u>Beating, stabbing</u>	<u>Blunt object impact</u>
Size of blood droplets:	Less than 1 mm	1-4 mm	4-6 mm
			

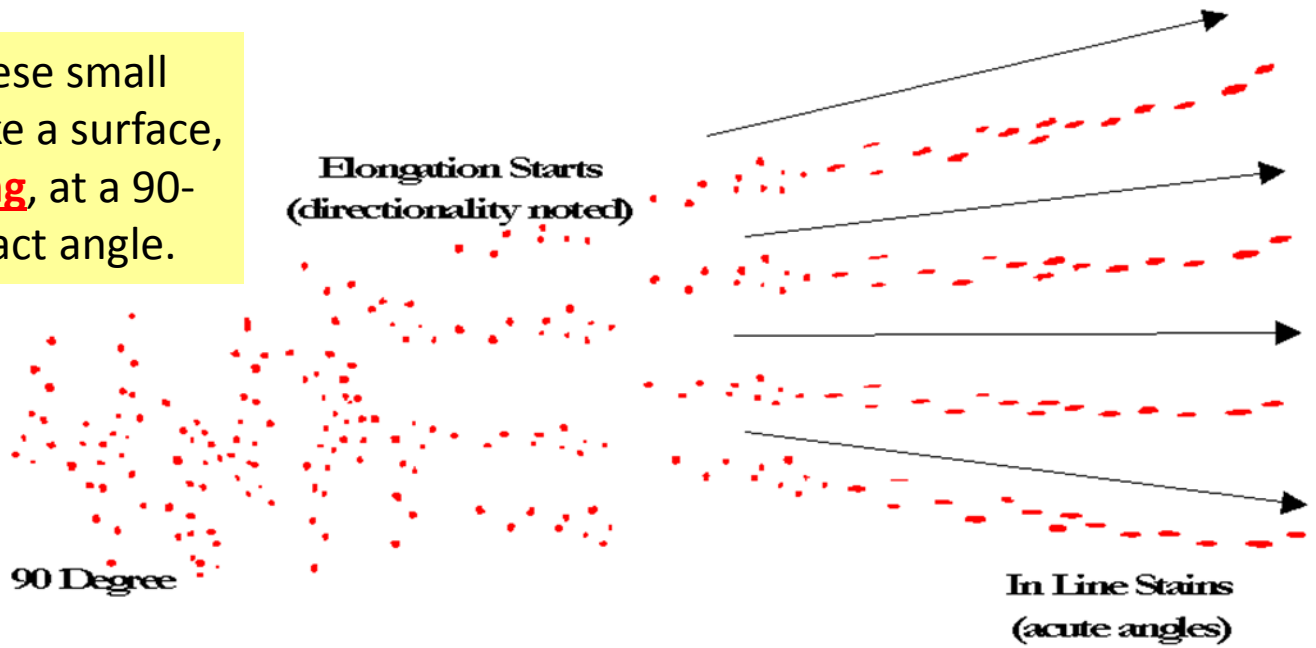




# CAST OFF

1. The movement and the number of swings can often be documented by examining the cast-off pattern.
2. During a beating with an instrument which produces the bleeding, blood will not normally collect on the surface of the instrument from the first strike.
3. On subsequent strikes at the same location, blood will adhere to the instrument since it now strikes a blood source. When the instrument is raised or swung backward, its movement allows small drops of blood to be released from its surface.

Some of these small drops will strike a surface, often a ceiling, at a 90-degree impact angle.



# BECOMING A BLOODSTAIN PATTERN ANALYST

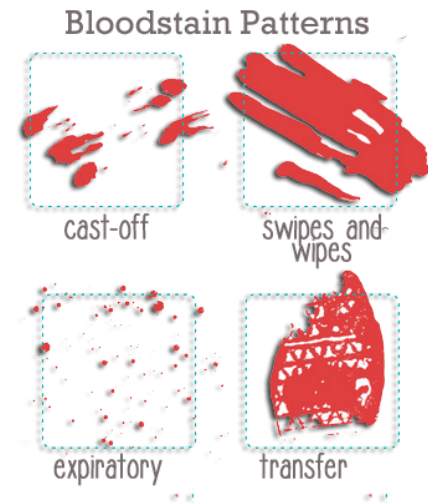
The field of bloodstain pattern analysis requires knowledge of math, physics, biology and chemistry. Students in Criminology and Criminal Justice learn about bloodstain pattern analysis in forensic science classes or classes specifically on blood spatter. But most analysts begin as law-enforcement officers who learn on the job, acquire certifications and take courses, workshops and seminars. Many train in bloodstain pattern (or blood spatter) analysis through the International Association of Bloodstain Pattern Analysis (IABPA). The IABPA developed criteria for the Basic Bloodstain Pattern Analysis Course, an introductory 40-hour course on the subject. Other organizations, such as the International Association for Identification (IAI), offer workshops and seminars as well as advanced courses which lead to certification in blood spatter analysis.

# IX. What is BPA?

## (Bloodstain Pattern Analysis)

- a. Analysis of bloodstain patterns left by falling, projected or smeared blood.
- b. Observation/measurement of position and shape of bloodstains give lots of info:

1. direction of travel
2. height above target
3. angle of impact
4. speed or velocity



- c. Provide a determination of the physical events responsible for their deposition

# Quote:

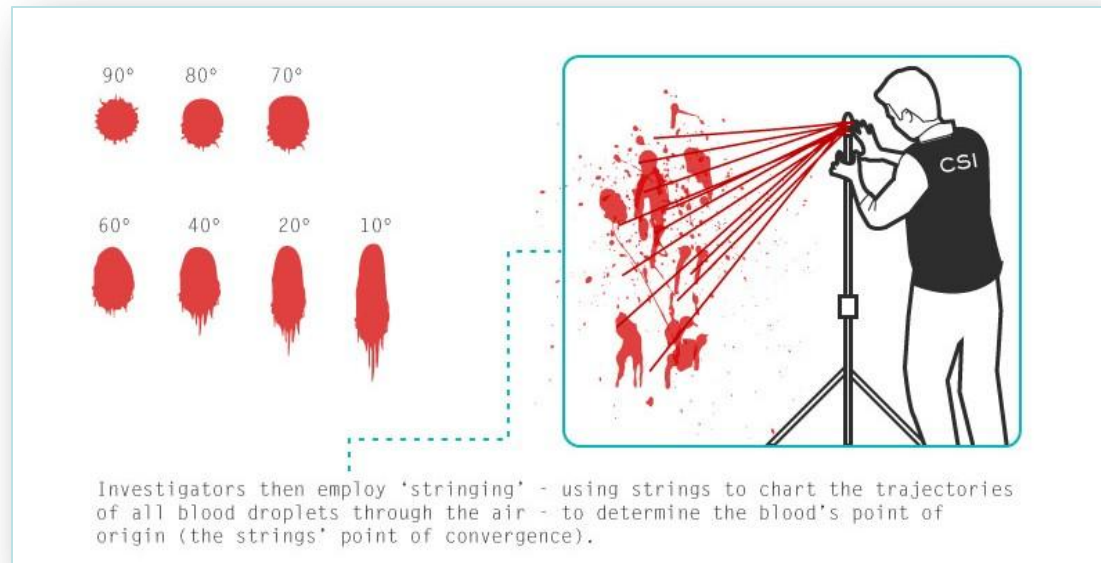
**“Through the examination of *bloodstains* and *bloodstain patterns*, in association with knowledge of the underpinning sciences, they provide a determination of the physical events responsible for their deposition.”**

*RCMP - Royal Canadian Mounted Police*



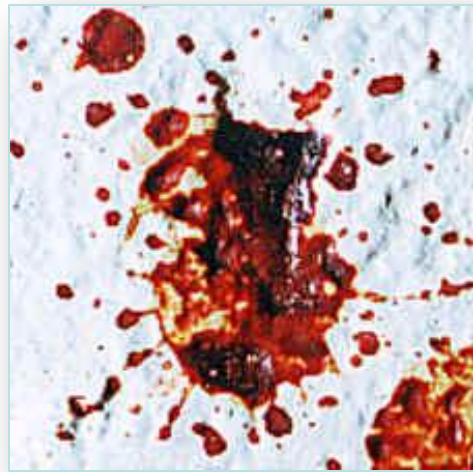
## d. Why is it important in Forensics?

1. can prove or refute a suspect's account of what happened
2. can possibly be used to reconstruct a crime
3. can tell us the “how” of a crime.



# X. Surface/Height & shape of blood drops

## A. Porous

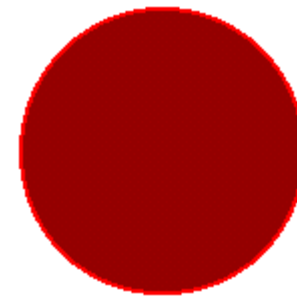


Concrete

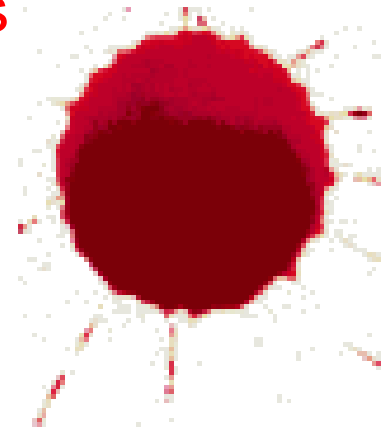


Wood

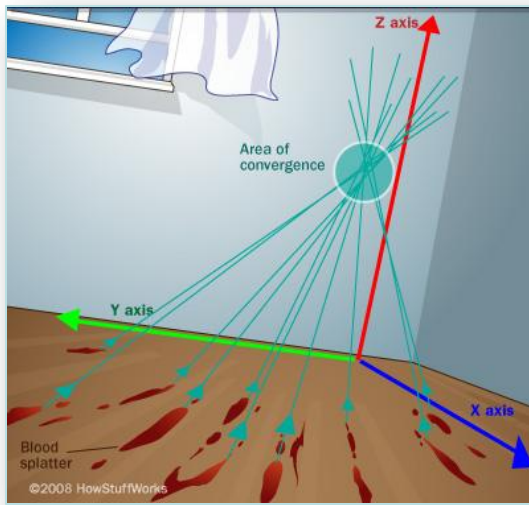
## B. Nonporous



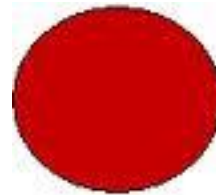
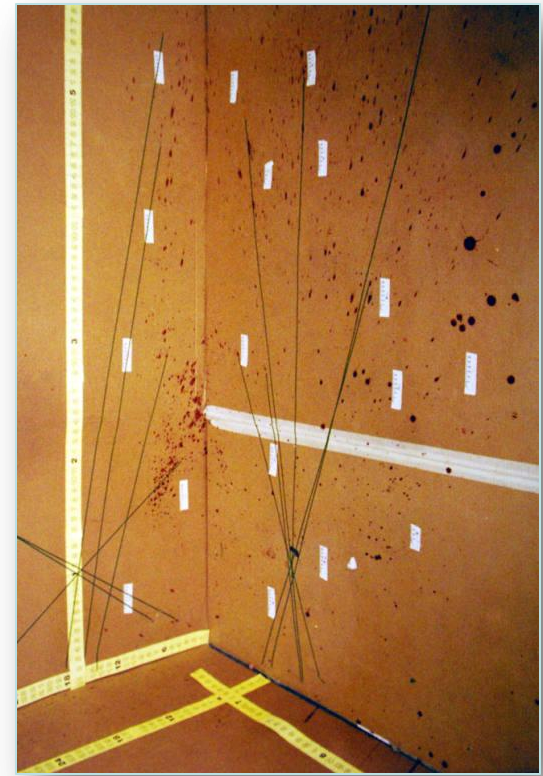
Glass



Linoleum



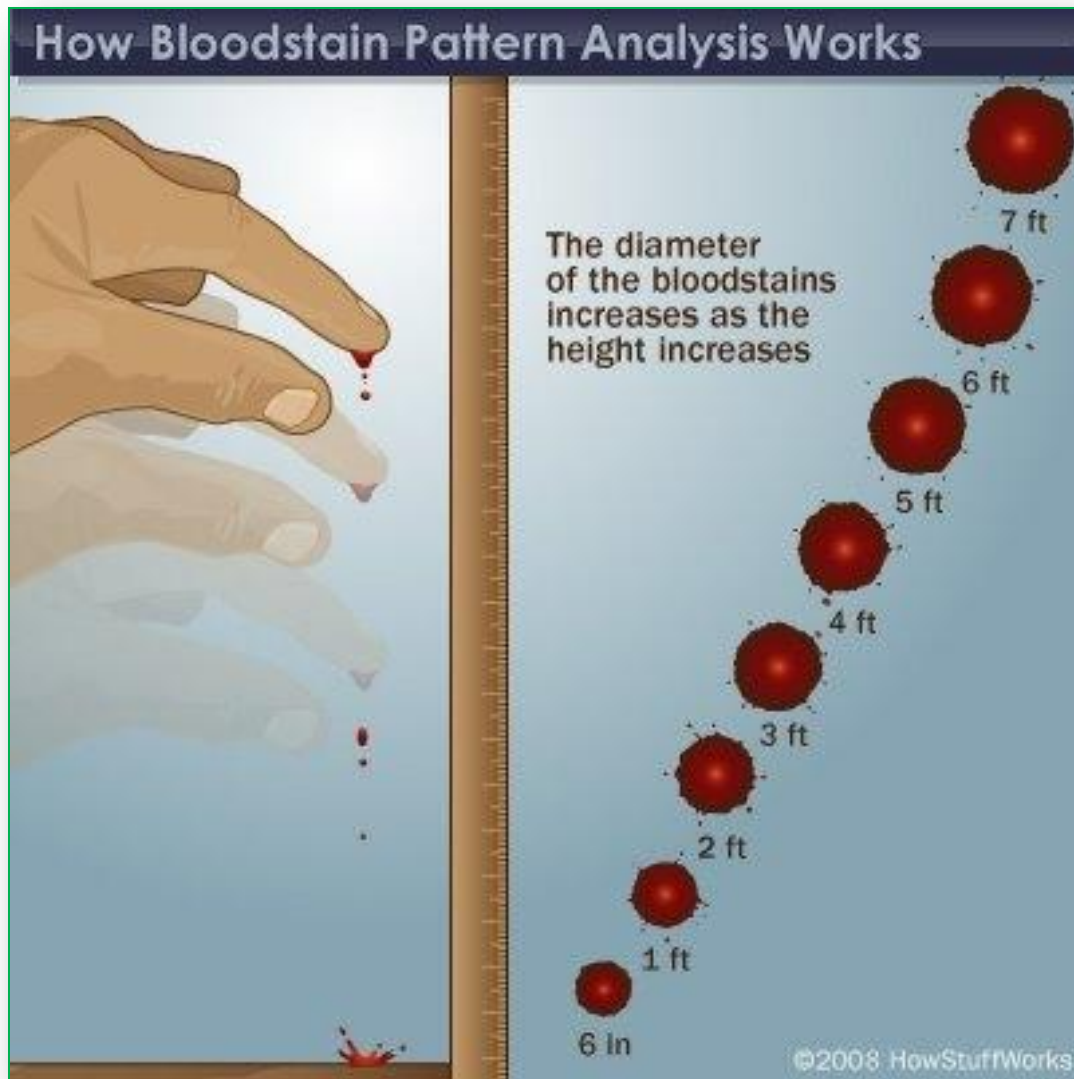
# Impact Types & Angle of Impact



**Blood Stain**  
**90° Angle**  
 onto a  
 smooth  
 surface.



**Blood Stain**  
**Acute Angle**  
 Note the projection  
 of the stain at one end.  
 That projection shows  
 the direction of travel.



\*Diameter of bloodstains ↑ = Height ↑



# XI. 3 Types of Impact

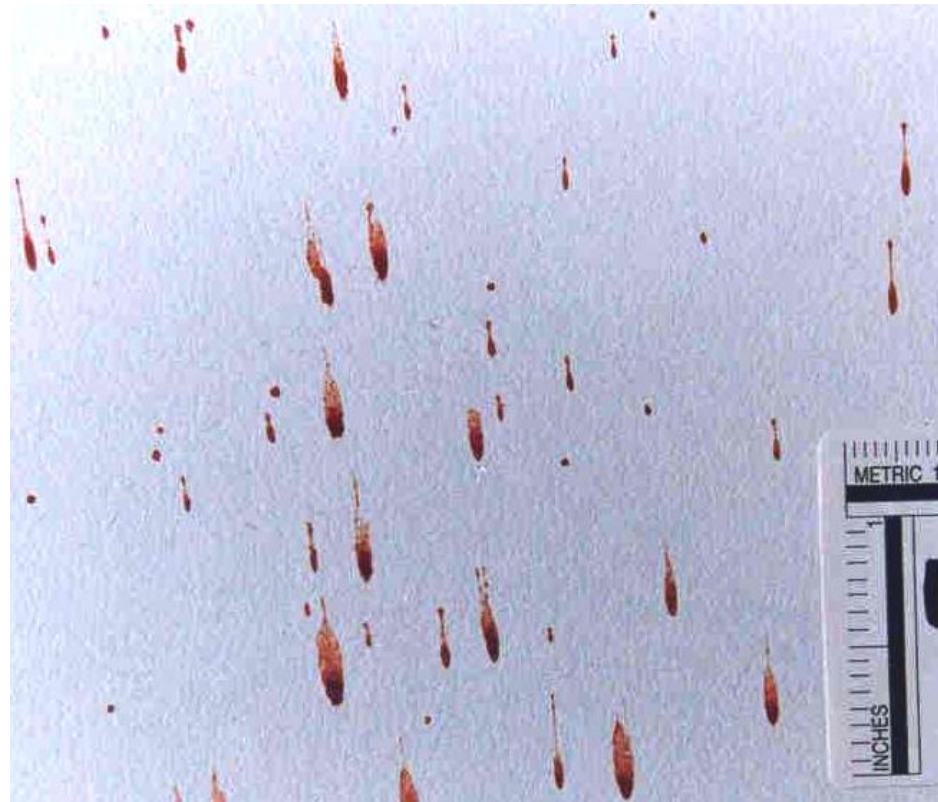
## **A. Low impact**

- **blood under the influence of gravity**
  - it just falls.
- **dripping**



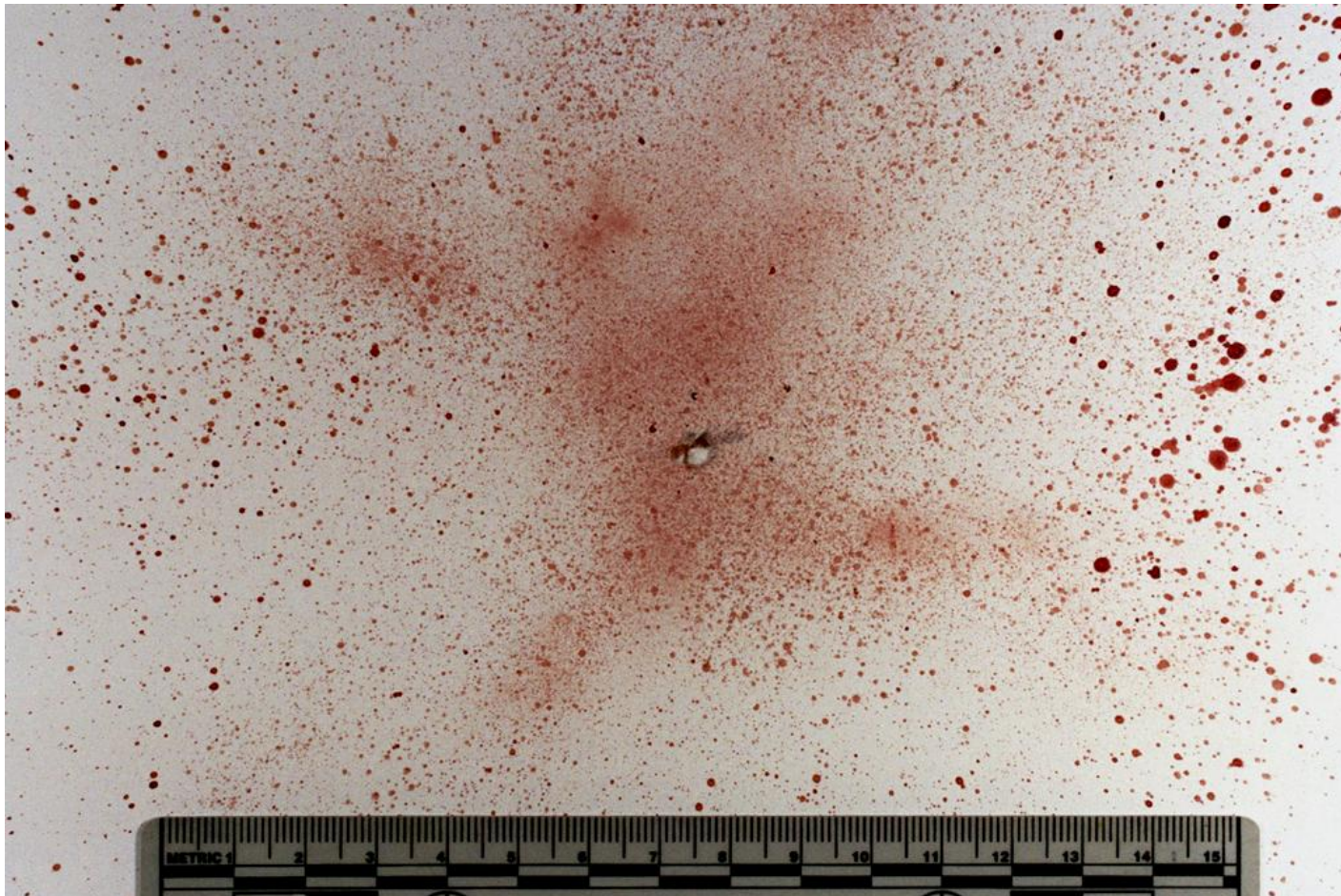
## B. Medium Impact

- **Medium impact occurs when a force, such as a bat, is applied.**

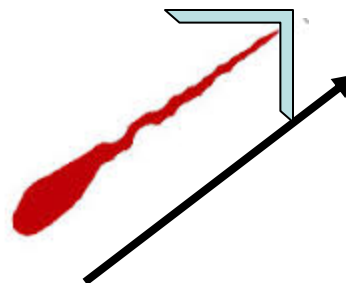
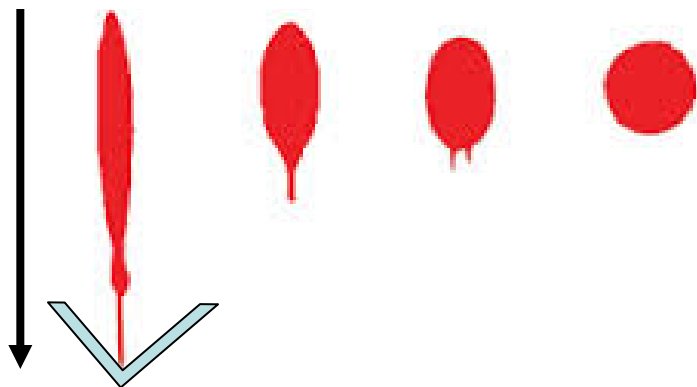


# C. High Impact

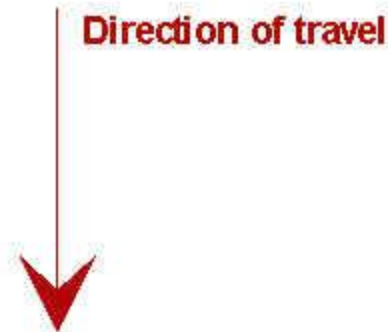
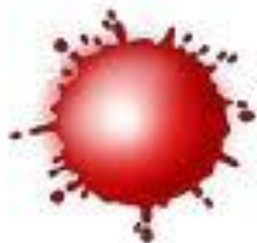
- fine mist of droplets
- gunshot, heavy machinery



# XII. Direction of Travel



- “The tail tells the tale”
- The tail points the direction the blood is going



# XIII. Calculating Angle of Impact

1. Measure WIDTH (*in cm.*)

- may be up and down, do not include spines

2. Measure LENGTH

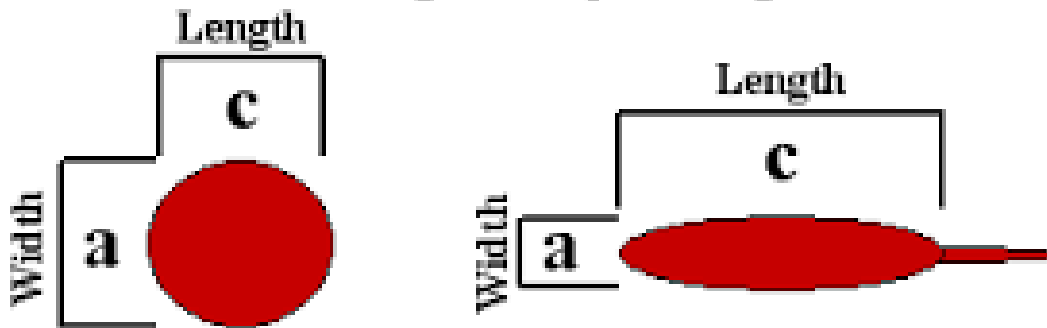
- do not include spines or tails

3. Formula:  $\text{Angle} = \sin^{-1} (\text{width}/\text{length})$

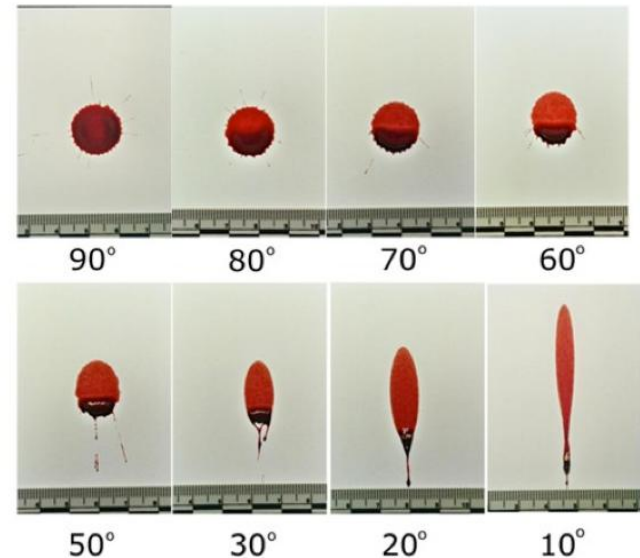


- divide smaller # by larger #

Calculating the Impact Angle



1. Measure the Width (a)
2. Measure the Length (c)



# WS: Angle of Impact Practice

\*\*MAKE SURE YOUR CALCULATOR IS IN DEGREES!!!

1.) Width = 1.0 mm.  
Length = 1.4 mm.

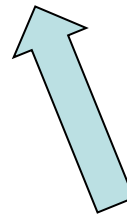
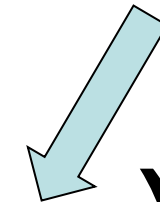
$$\text{Angle of Impact } ^\circ = \text{Sin}^{-1} \times \left( \frac{\text{Width}}{\text{Length}} \right)$$

$$\text{A.O.I.}^\circ = \underline{\hspace{2cm}}^\circ$$

$$\text{Sin}^{-1} \times \left( \frac{1.0}{1.4} \right) =$$

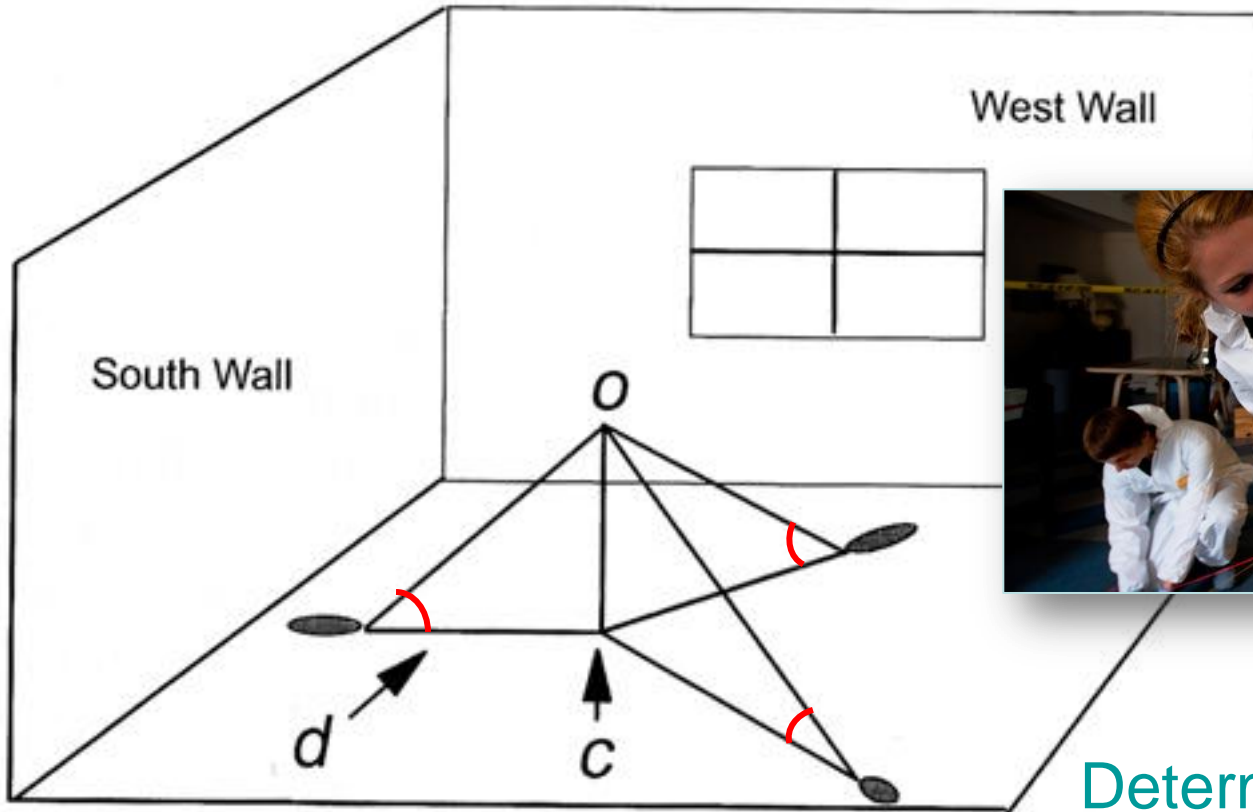
$$\text{Sin}^{-1} \times (0.714) =$$

Smaller #



Larger #

# Origin of Blood



Determining Area of Origin

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

