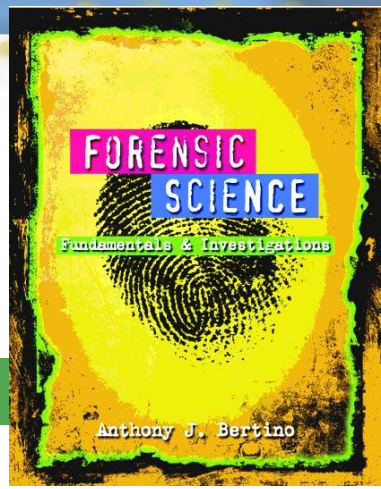
Chapter 8 ***Blood and Blood Splatter***



By the end of this chapter you will be able to:

- Explain the composition of blood
- Describe the function of blood cells
- Determine the blood type of a blood sample
- Conduct a blood splatter analysis
- Examine wounds and describe the nature of the weapon
- Find and process blood evidence

Introduction and History

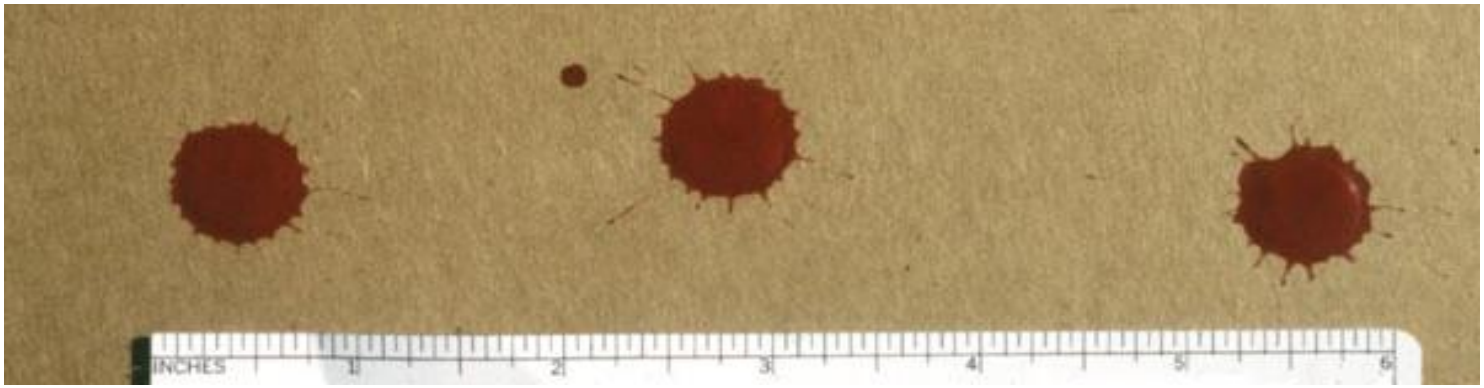
- Blood typing provides class evidence
- More than one person has the same blood type
- DNA profiling provides individual evidence
- Need white blood cells
- A blood splatter pattern provides information
  - the truthfulness of an account by a witness or a suspect
  - the origin of the blood
  - the angle and velocity of impact
  - the type of weapon used

Composition of Blood

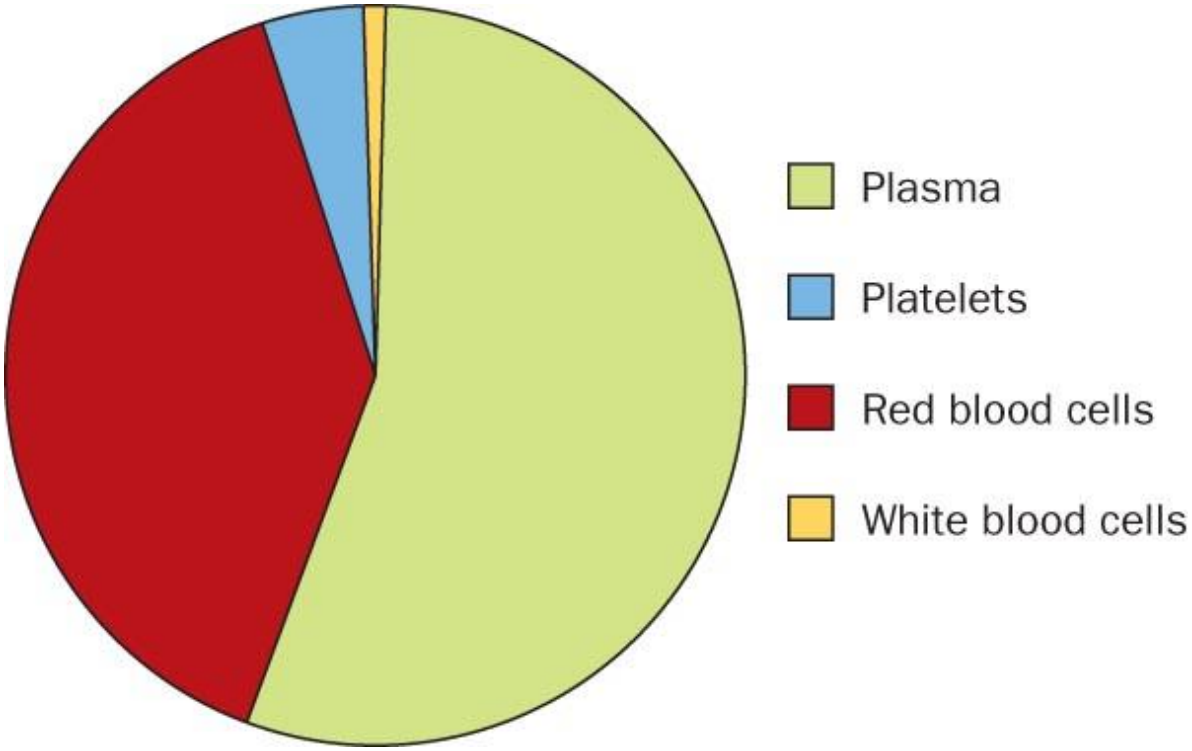
- **Plasma**—a liquid suspending other blood components
- **Red blood cells (Erthrocytes)**—carries oxygen to the body's cells and carbon dioxide away
- **White blood cells (Leukocytes)**—fights disease and foreign invaders and, alone, contain cell nuclei
- **Platelets**—aids in blood clotting and the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

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



Composition of Blood

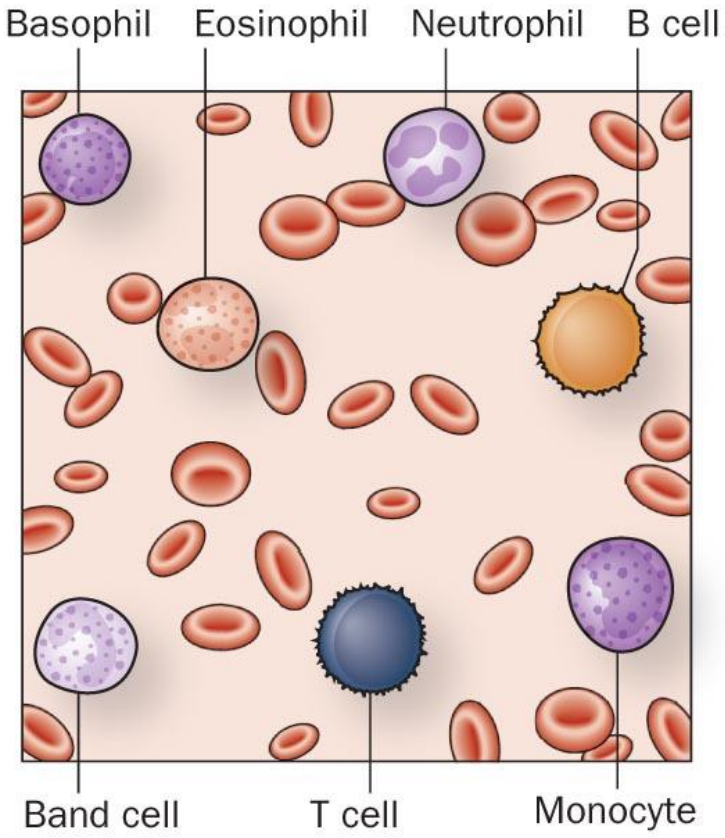


Composition of Blood

*only write underlined part

- **RED BLOOD CELLS** (Erythrocytes) –Produced in the bone marrow, contain a protein called **hemoglobin** that carries oxygen to our cells.
- **WHITE BLOOD CELLS** (Leukocytes) –Part of the **immune system** and destroy infectious agents called pathogens.
- **PLASMA** –Yellowish **liquid portion** of blood that contains electrolytes, nutrients and vitamins, hormones, clotting factors, and proteins such as antibodies to fight infection.
- **PLATELETS** (Thrombocytes) –They clot together in a process called coagulation to seal a wound and prevent a loss of blood.

Types of Blood Cells



Interesting Blood Facts

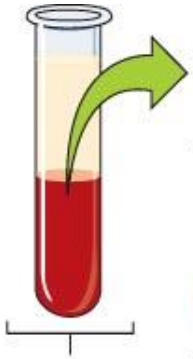
*FYI

The average adult has about **FIVE** liters of blood inside of their body, which makes up 7-8% of their body weight.

Blood is living **tissue** that carries oxygen and nutrients to all parts of the body, and carries carbon dioxide and other waste products back to the lungs, kidneys and liver for disposal. It also fights against **infection** and helps heal **wounds**, so we can stay healthy.

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.

Cellular Components of Blood



Cellular elements 45%

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

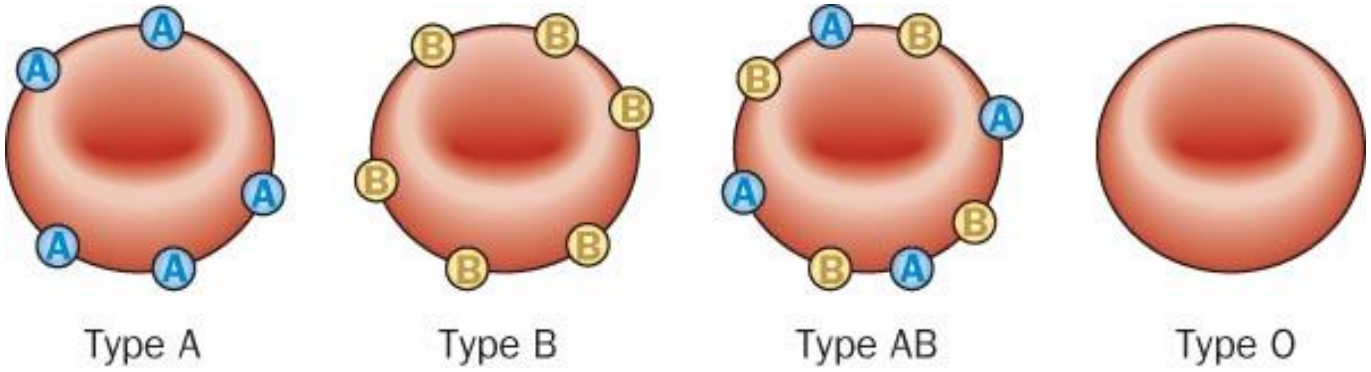
Blood Typing—Proteins

- Discovered in 1900 by Karl Landsteiner
- Identifies the presence or absence of particular proteins embedded in the cell
- Quicker and less expensive than DNA profiling
- Produces class evidence but can still link a suspect to a crime scene or exclude a suspect
- Blood did not always freely mix with blood from another person.

Genetics of Blood Types

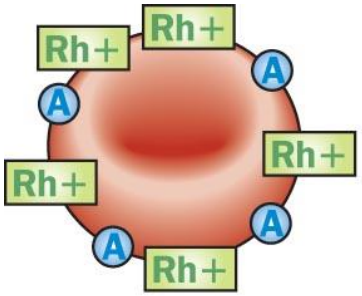
*FYI

- 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.

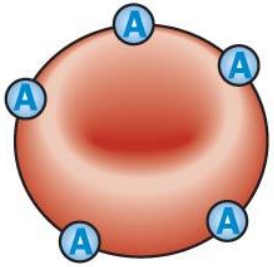


Rh Factor

85% of the population has a protein called RH factor on their blood cells



Protein A present
Rh protein present
Type A+



Protein A present
Rh protein absent
Type A−

Rh Factors

*FYI

- Scientists sometimes study **Rhesus monkeys** to learn more about the human anatomy because there are certain similarities between the two species. While studying Rhesus monkeys, a certain blood protein was discovered. This protein is also present in the blood of some people. Other people, however, do not have the protein.

- The presence of the protein, or lack of it, is referred to as the Rh (for **Rhesus**) factor.

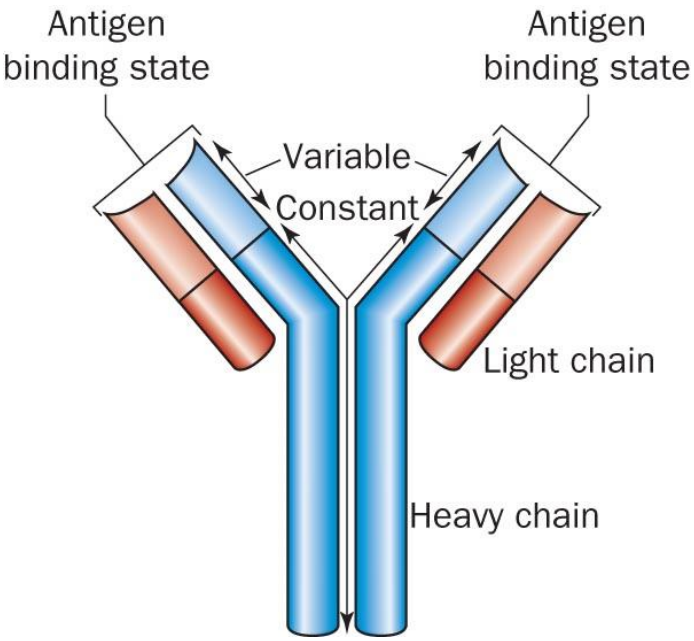
- If your blood does contain the protein, your blood is said to be Rh **positive** (Rh+). If your blood does not contain the protein, your blood is said to be Rh **negative** (Rh-).

A+ A-
B+ B-
AB+ AB-
O+ O-

http://www.fi.edu/biosci/blood/rh.html

Blood Typing—Antibodies

- **Antibodies** are Y-shaped proteins secreted by white blood cells that attach to antigens to destroy them
- **Antigens** are foreign molecules or cells that react to antibodies



Blood Enzymes

- **Enzymes** are complex proteins that catalyze different biochemical reactions
- Many enzymes and proteins have been found in the blood that are important for identification purposes

Blood Typing —Probability and Blood Types

- The probability of a blood type equals the product of probabilities for each protein group

  If **Type A = 42%** and **Rh Factor = 85%**

  Then **A+ = .42 x .85 = .357 (35.7%)**

- Knowing additional proteins and enzymes in the blood sample
  - Narrows the population group
  - Increases the probability of identifying a suspect

Blood Typing

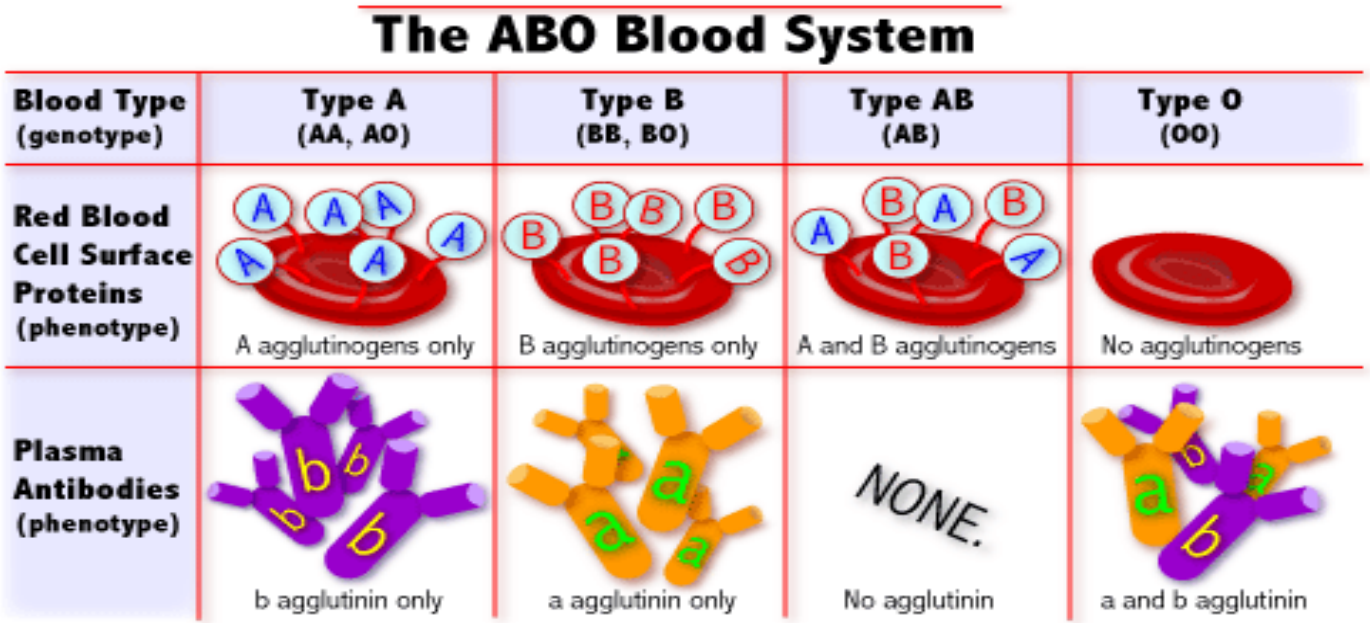
There are 3 alleles or genes for blood type: A, B, & O.

Blood typing is codominant

= Both dominant alleles show up, ex. AB

Blood Types

AA or AO = Type A
BB or BO = Type B
OO = Type O
AB = Type AB



http://learn.genetics.utah.edu/units/basics/blood/types.cfm

How common is your blood type?

*FYI

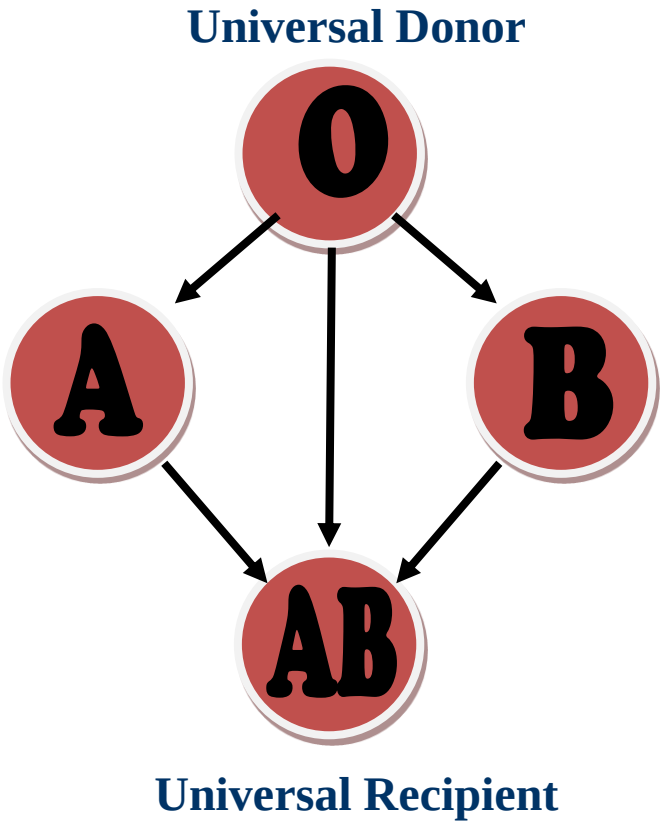
TYPE	DISTRIBUTION	RATIOS	
O +	1 person in 3	38.4%	46.1%
O -	1 person in 15	7.7%	
A +	1 person in 3	32.3%	38.8%
A -	1 person in 16	6.5%	
B +	1 person in 12	9.4%	11.1%
B -	1 person in 67	1.7%	
AB +	1 person in 29	3.2%	3.9%
AB -	1 person in 167	0.7%	

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

Donating Blood

Who can give you blood?

- **TYPE O** blood is the **Universal Donor,** because it can be given to any blood type.
- **TYPE AB** blood is the **Universal Recipient,** because it can receive any blood type.
- **Rh + → Can receive + or -**
- **Rh - → Can only receive -**

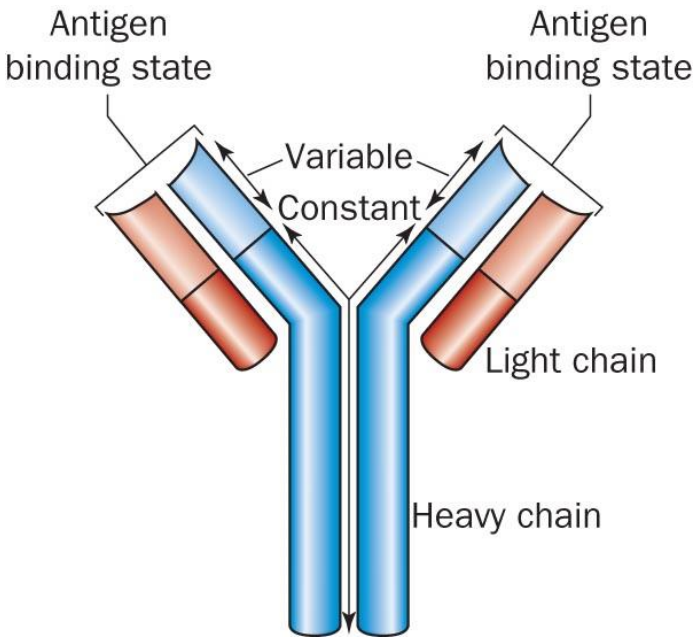


Blood Type and Antibodies

- When a person receives a blood protein (AB or RH) that is foreign to him/her, antibodies will cause the blood to clump, may cause death.
- **Antibodies:** help identify foreign bodies; bind to the **antigen** (foreign body)

*FYI

Antigen-Antibody Response: the attack launched against a foreign invader (viruses, bacteria, allergens)



Remember Agglutinogens?

- Review: The genes from parents determine your blood type by causing proteins called **AGGLUTINOGENS** to exist on the surface of all of your red blood cells.
- **Agglutination: clumping of RBCs**
- Can cause clots, ceasing blood flow

Predicting Blood Type

using Punnett Squares!

Blood Types

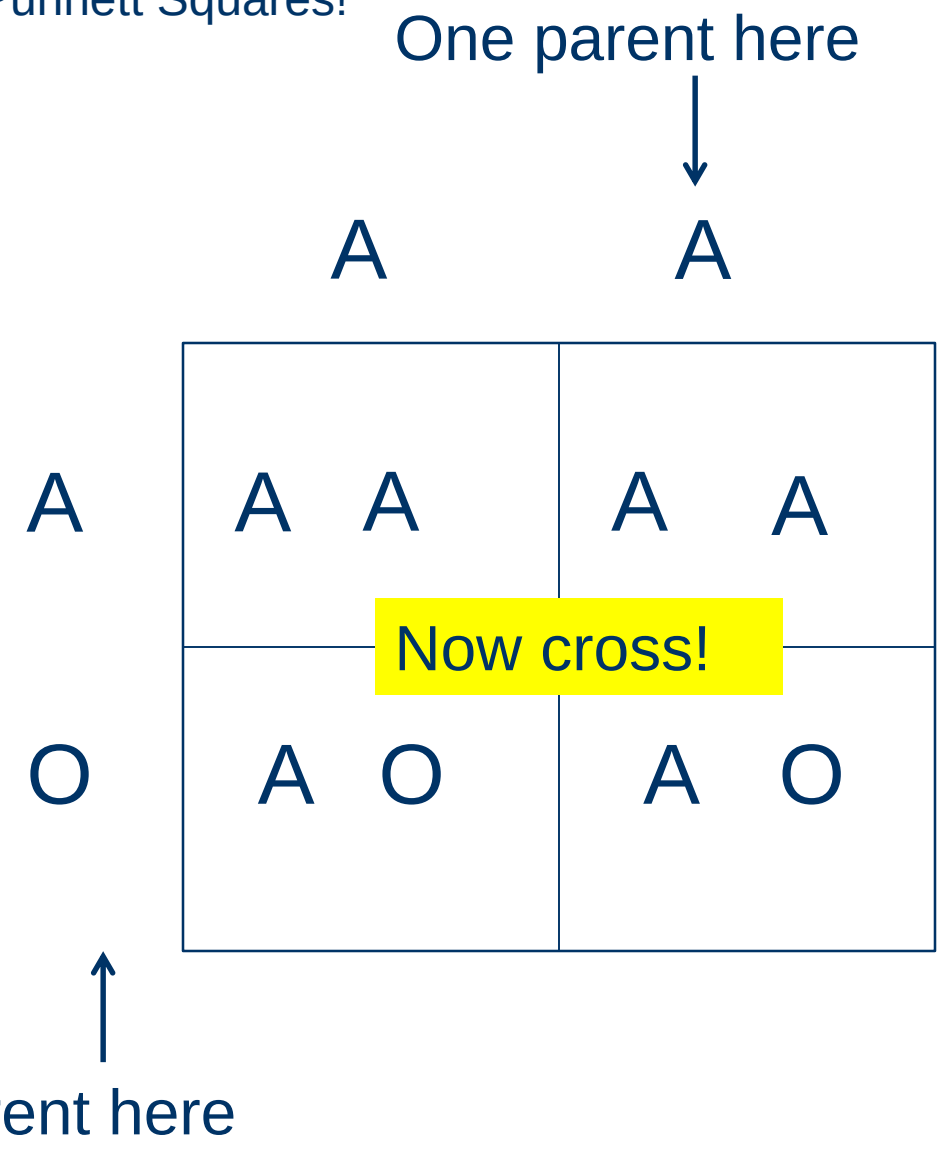
Type A
- Homozygous = AA
- Heterozygous = AO

Type B
- Homozygous = BB
- Heterozygous = BO

Type O = OO

Type AB = AB

Results:
AA = 50%
AO = 50%



Practice in your notebook!

Blood Types

Type A
- Homozygous = AA
- Heterozygous = AO

Type B
- Homozygous = BB
- Heterozygous = BO

Type O = OO

Type AB = AB

1. AO x AB

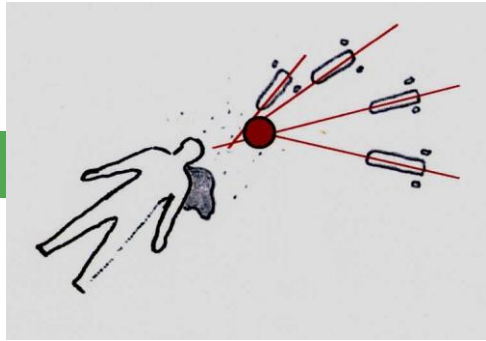
	A	B
A		
O		

2. AB x AB

3. Homozygous type B with heterozygous type A

4. Heterozygous type A with heterozygous type B

Blood Splatter



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

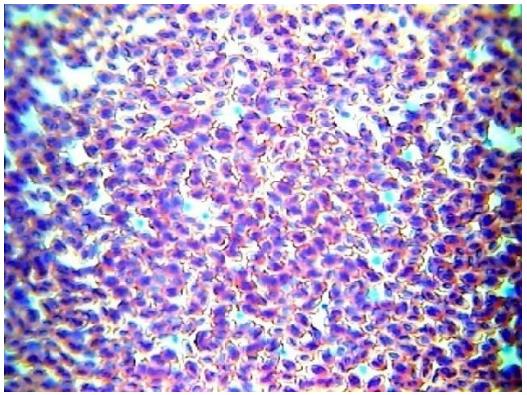
Blood Evidence

- **Blood samples** – analyzed to determine **blood type** and **DNA,** which can be matched to possible suspects.

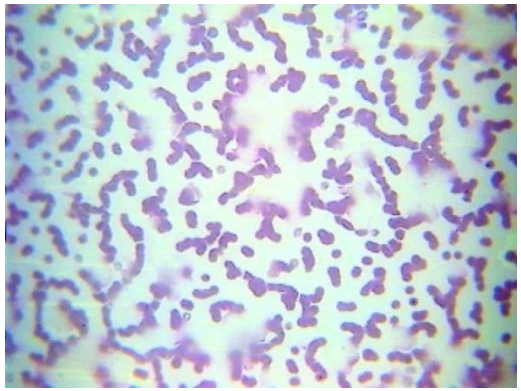
- **Blood droplets** – analyzed to give clues to the location of a **crime,** movement of a **victim,** and type of **weapon.**

- **Blood spatter** – analyzed to determine **patterns** that give investigators clues to how a crime might have happened.

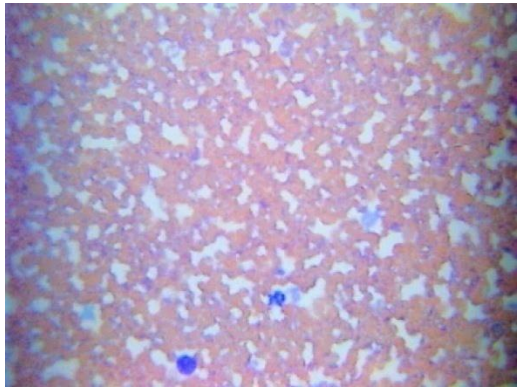
Microscopic Views



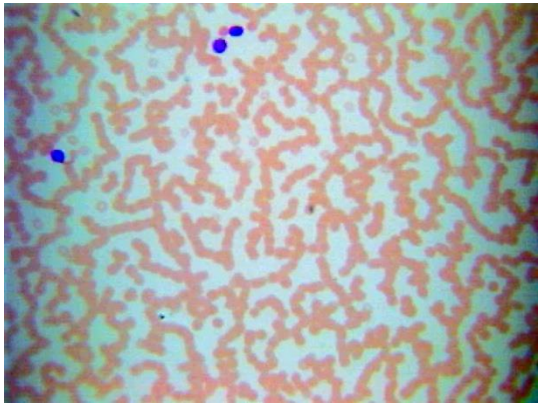
Bird Blood



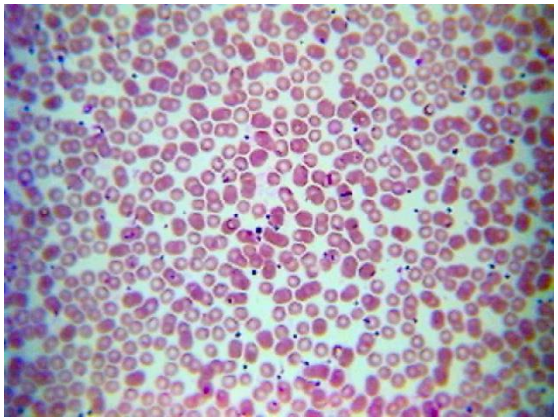
Cat Blood



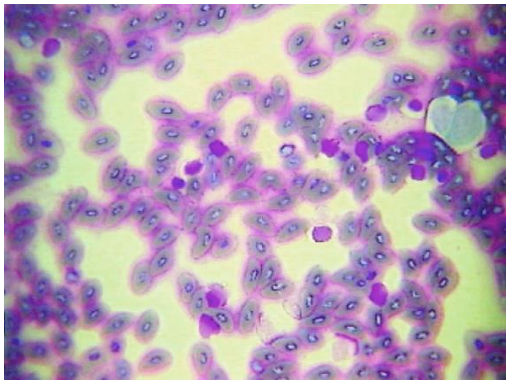
Dog Blood



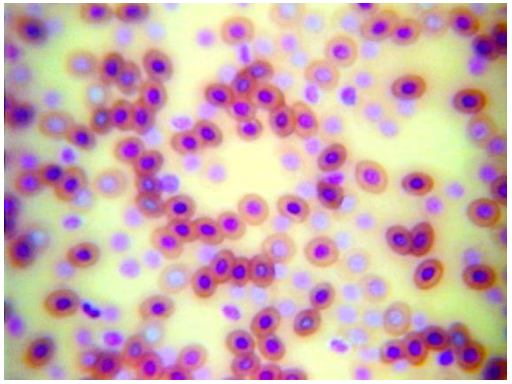
Horse Blood



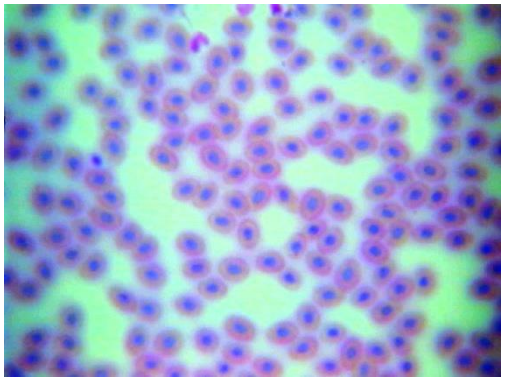
Human Blood



Fish Blood



Frog Blood



Snake Blood

Examples: *write down bolded part only

- **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**.

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.

Fluorescein Reaction in UV Light

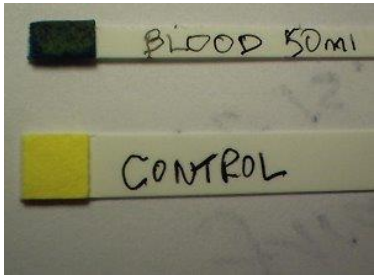
How is blood evidence detected at a crime scene?

- **Light Source – high intensity or UV light**

FYI: 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 – determine if blood is present**

FYI: 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 Presumptive Blood Test

- Presumptive test: will only reveal the possibility that the substance is blood or tell us for certain that the substance is not blood
- Based on the reaction of hemoglobin with phenolpthlalein in the presence of hydrogen peroxide (H_20_2).
- Hemoglobin is the iron-containing, oxygen-transport protein in RBCs.
- Iron in hemoglobin reacts with H_20_2
  - Breaks it into H_20 and a free oxygen radical (0)
  - Free oxygen radical reacts with phenolpthlalein and turns the indicator bright pink/fuschia

Luminol Presumptive Blood Test

- Hemoglobin reacts with peroxide, forming the free oxygen radical.
- The free radical is in an excited state and oxidizes luminol, which also enters an excited state.
- As the luminol falls back to its ground state, light is emitted.

Blood Splatter Analysis

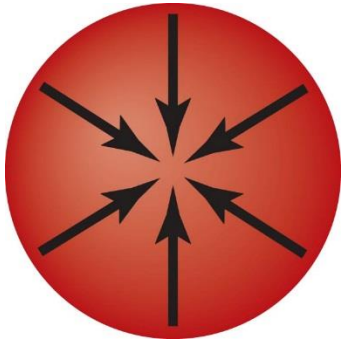
Analysis of a splatter pattern can aid in determining the:

- direction blood traveled and distance traveled
- angle of impact
- point of origin of the blood
- velocity of the blood
- manner of death

- Position of victim and assailant
- Movement of victim and assailant

Blood Splatter Analysis

Natural cohesiveness of blood

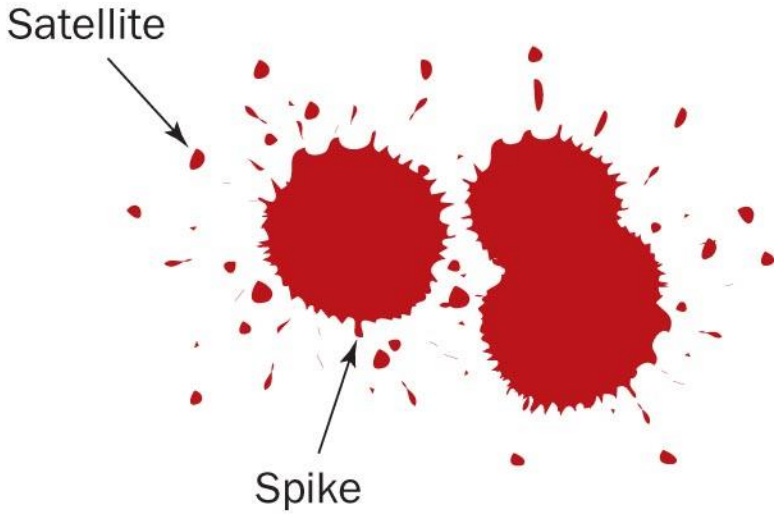


Bloodstain Pattern Analysis Terms

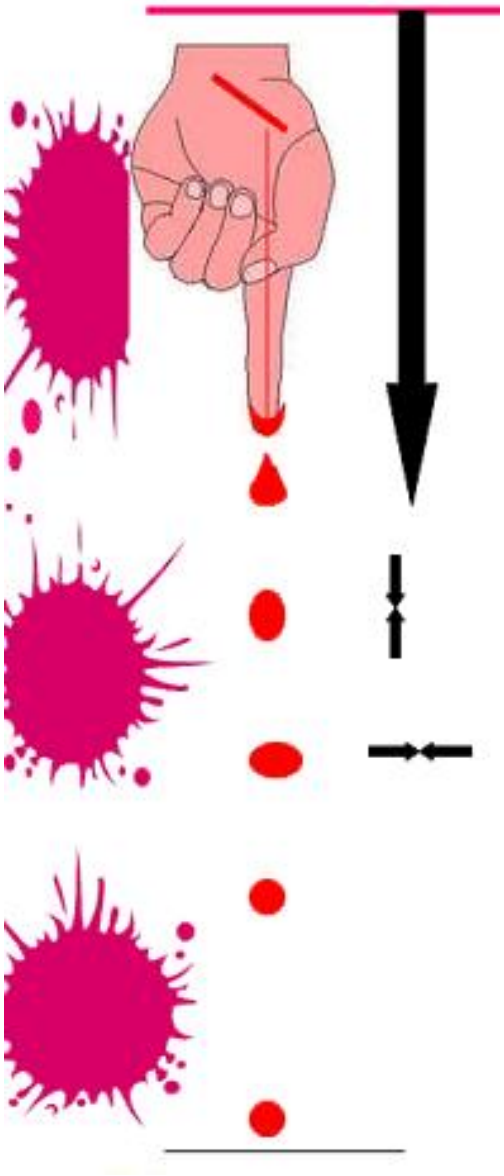
- **Spatter** – Bloodstains created from the application of force to the area where the blood originated.
- **Angle of Impact** – The angle at which a blood droplet strikes a surface.

Blood Splatter 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

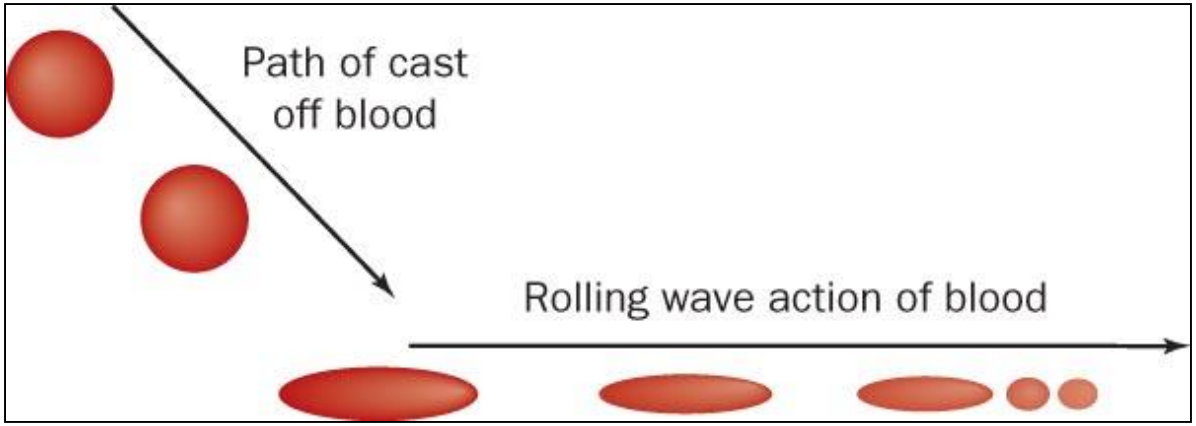


Dripping Blood



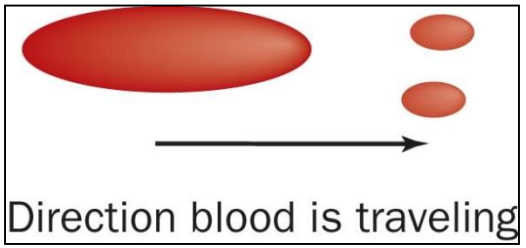
- Blood trickles downwards
- Blood drop grows until weight exceeds surface tension (cohesion)
- Single drop breaks free (teardrop shape)
- Surface tension pulls it vertically
- And horizontally
- Shape settles into sphere
- Does not break up until impact

Blood Splatter Analysis —Directionality



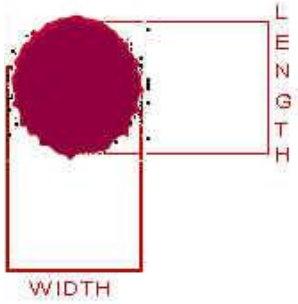
The shape of an individual drop of blood provides clues to the direction from where the blood originated.

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

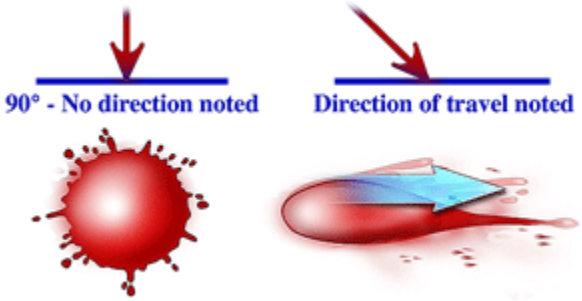


Examination of Directionality of Blood

- Circular drop: width and length are equal; fell straight down; 90 degree angle
- Elongated drop: longer than it is wide; indicates direction blood was traveling

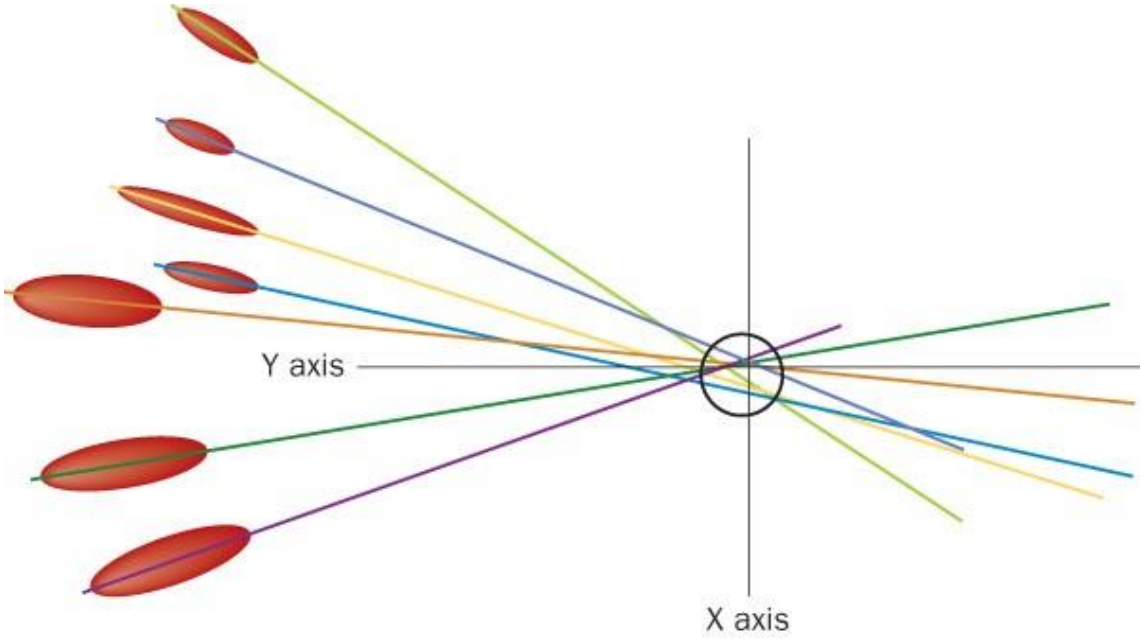


90 Deg Stain
No Direction noted



Blood Splatter Analysis

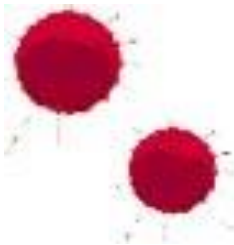
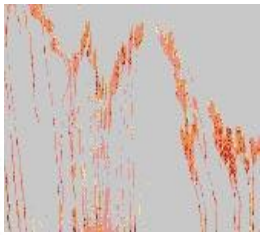
Lines of convergence—two or blood splatters can pinpoint the location of the blood source

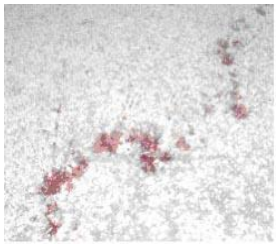


Patterns of Blood Spatter

1. Passive fall: Blood falling to the floor at a 90-degree angle will produce circular drops. Satellites will form if the surface is textured.
2. Arterial spurts or gushes: found on walls or ceilings; caused by pumping action of heart
3. Splashes: shaped like exclamation points. Shape and position of the pattern can help locate position of victim at the time of attack.
4. Smears: Left by a bleeding victim as s/he brushes against an object
5. Trails: left by a bleeding victim as s/he moves from one place to another
6. Pools: victim is bleeding heavily and remains in one place

Blood Splatter Analysis —Six Patterns

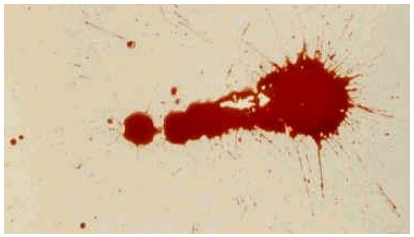

Describe each of these:

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

Types of Bloodstain Patterns

- **Passive Bloodstains**

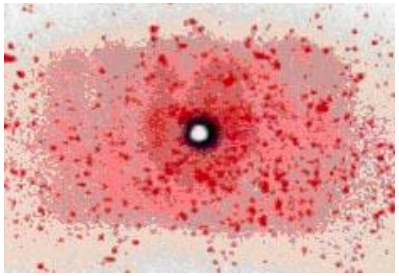
- **Projected Bloodstains**



- **Transfer or Contact Bloodstains**

Images from http://www.bloodspatter.com/BPATutorial.htm

Blood Splatter Analysis —Impact

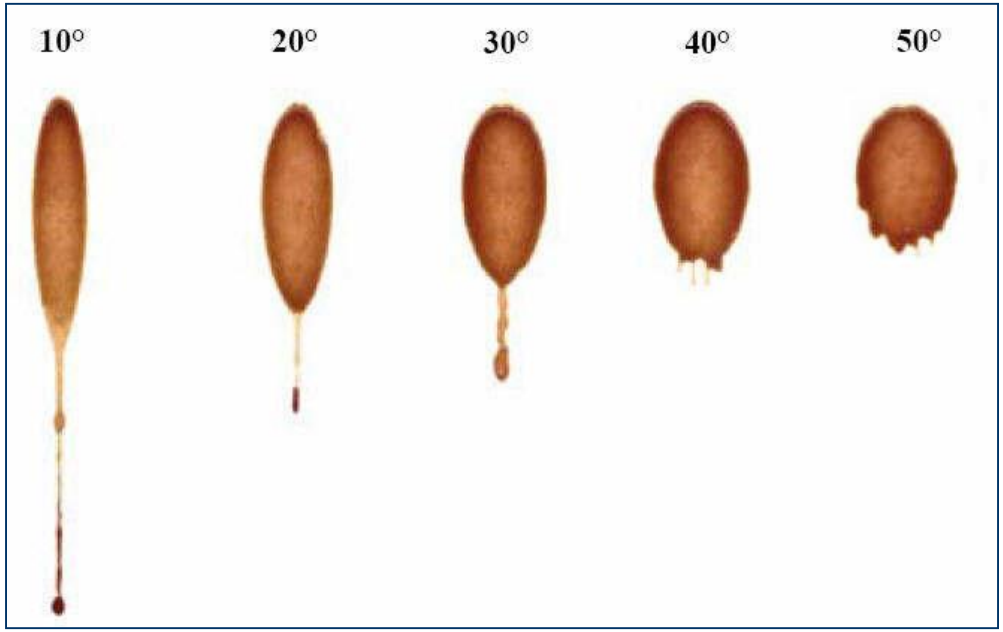


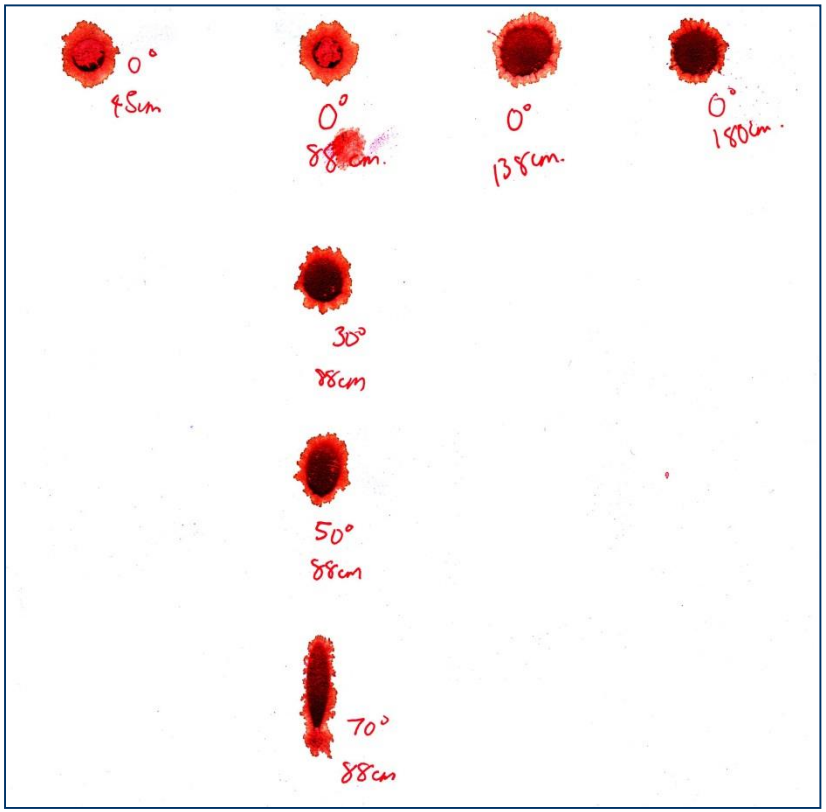
Patterns can help investigators determine the type of weapon used

- What kind of a pattern is produced by a gun shot?
- What kind of a pattern is produced by a hammer blow?

Lab 3: Drop Patterns from an Angled Impact

Arc sin of width/length = impact angle





Crime Scene Investigation of Blood

1. Search for blood evidence
2. Determine
   a. Is the evidence blood?
   b. Is the blood human?
   c. What is the blood type?
3. Interpret the findings:
   a. Does the blood type match a suspect's blood?
   b. If not, exclude that suspect
   c. If yes, decide if DNA profiling is necessary

Crime-Scene Investigation of Blood

Steps taken in processing a blood stain:

1. Confirm the stain is blood.
    - Kastle-Meyer
    - Luminol
    - Leukomalachite green (produces a green color in presence of blood)
2. Confirm the blood is human.
3. Determine blood type.

Summary

- Blood consists of cellular components and plasma.
- The various human blood types are caused by the presence or absence of A and/or B proteins on the surface of red blood cells.
- Blood splatter evidence can be used to recreate a crime scene.
- Investigators endeavor to (a) locate, (b) identify, and (c) interpret blood splatter patterns at crime scenes.