

Forensic Serology

GAVS 11

SFS3 Students will analyze the use of toxicology, serology, and DNA technology in forensic investigations.

- d. Differentiate the forensic techniques used to distinguish human and animal blood
- e. Analyze the physics of blood stain patterns.
- f. Compare short tandem repeat patterns (STR) and relate to identifying the DNA of an individual.
- g. Explain the use of the DNA database for DNA profiling.

SFS5 Students will evaluate the role of Forensics as it pertains to Medicolegal Death Investigation.

- a. Identify various causes of death (blunt force trauma, heart attack, bleeding, etc.).
- b. Analyze evidence that pertains to the manner of death (natural, homicide, suicide, accidental, or undetermined).

Learning Targets: I can

- Describe ways serological evidence helps solve a crime.
- Identify the type of information can be determined from a drop of blood.
- Describe how is blood typing done.
- Decipher the information we get from blood stain patterns.
- Describe how is blood analyzed in the Forensic lab.
- Demonstrate how paternity is established through blood testing.

Serology

- The medical science dealing with serums found in blood, semen, saliva, sweat, or fecal matter.
- We will primarily focus on blood serum.
 - Blood serum is the yellow fluid (plasma) that separates from the solid components when whole blood is centrifuged.

Types of evidence obtained from serological examinations

1. Blood type and other identifying characteristics in of the blood sample.
2. Toxins, drugs, or other substances within the blood.
3. Possible identification of disease processes that may be visible in the blood.
4. Bloodstain pattern analysis.
5. DNA Profile
6. Expert testimony evidence pieces

Why Serology Evidence is important in Forensics

1. It can provide a link from victim to suspect.
2. Bloodstain patterns can provide a wealth of information about the crime, such as where it took place, how it progressed and even clues to the weapons used.
3. Serology evidence can help support a suspect's statement leading to exoneration or it can contradict what the suspect may have stated implying some possibility of involvement in the crime.
4. Serology evidence can also differentiate between human evidence and other animal evidence that may also be found at a crime scene.

Structure and Function of Blood

- Primary function of blood is to transport gases such as oxygen and carbon dioxide, distribute nutrients such as glucose, and provide defenses for the body such as platelets for blood clotting and antibodies to fight bacteria, viruses, and foreign substances.
- Red blood cells – erythrocytes – carry oxygen from the lungs to your body's tissues and take CO₂ back to your lungs to be exhaled.
 - Surfaces have antigens that stimulate the immune system
- Antibodies are various proteins produced in response to the presence of an antigen. Antibodies fight off intruder cells, such as bacteria or viruses.
- White blood cells – leukocytes – travel throughout the body and destroy bacteria, some produce antibodies against bacteria and viruses, and other help fight malignant diseases
 - DNA is gathered from the white blood cells in blood samples.

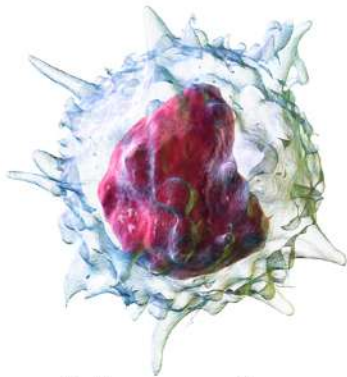
Formed Elements of Blood



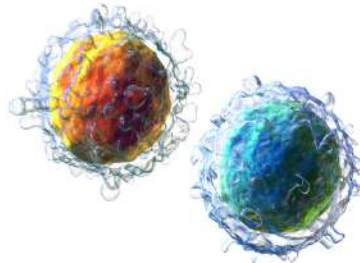
Red Blood Cells



Platelets



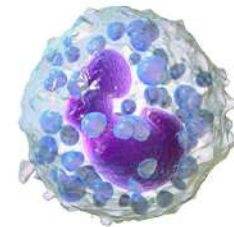
Monocyte



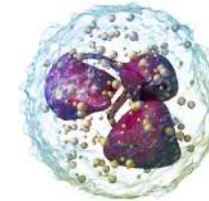
Lymphocytes



Eosinophil



Basophil



Neutrophil

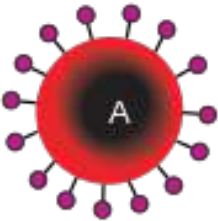
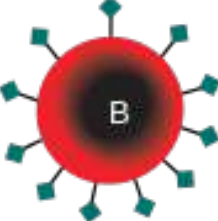
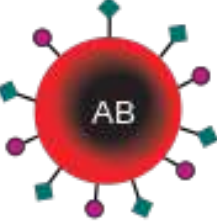







White Blood Cells

Structure and Function of Blood (cont)

- Platelets – thrombocytes – small, colorless fragments in the blood whose main function is to interact with clotting proteins to stop or prevent bleeding.
- Plasma is the liquid portion of blood composed of 92% water, 7% vital proteins such as albumin, gamma globulin, antihemophilic factor, and 1% mineral salts, sugars, fats, hormones, and vitamins. Plasma ensures blood moves effectively through the circulatory system.

Blood Types

- Blood is classified into 8 basic blood types based on antigens and antibodies in the blood. First classified by the ABO group and then by the Rh Factor, creating A⁺, A⁻, B⁺, B⁻, AB⁺, AB⁻, O⁺, O⁻.

	Group A	Group B	Group AB	Group O
Red blood cell type				
Antibodies in Plasma	 Anti-B	 Anti-A	None	 Anti-A and Anti-B
Antigens in Red Blood Cell	 A antigen	 B antigen	 A and B antigens	None

Blood Types

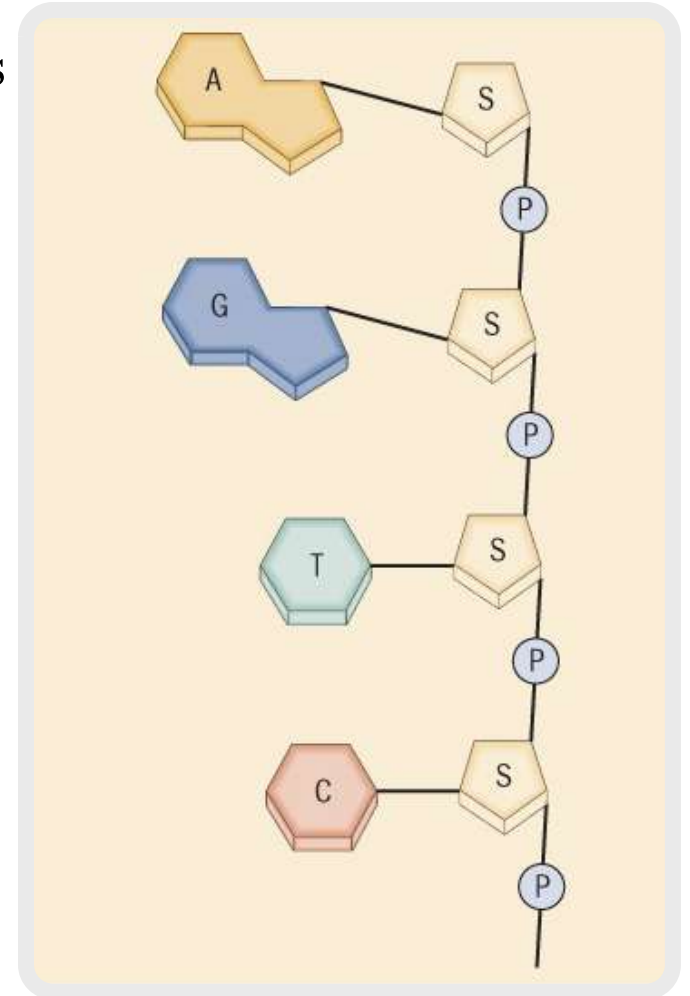
- Antibodies produced by the A blood group remove any RBCs containing B antigens by clumping them together. (Vice versa for B blood group.) Blood type O will not clot at all since it contains no antigens for the A or B antibodies.
- The Rh factor causes clotting in those Rh positive.
- Blood type is very important in blood transfusions.
- Blood type is class evidence because everyone essentially has one of the 8 blood types.
- DNA is considered individual evidence

DNA

- Deoxyribonucleic acid (DNA) makes up genes which make up chromosomes.
- Each person inherits 2 sets of genes (one from each parent).
- Different forms of genes are called alleles.
- The pair of alleles inherited are the person's genotype.
- The phenotype is the observable characteristic of the person.
- There are 3 alleles for blood: A, B, and O.
 - A and B are dominant over O.
 - Blood genotype would include both alleles. Example: AO
 - The phenotype would be A because A is dominant and O is recessive.

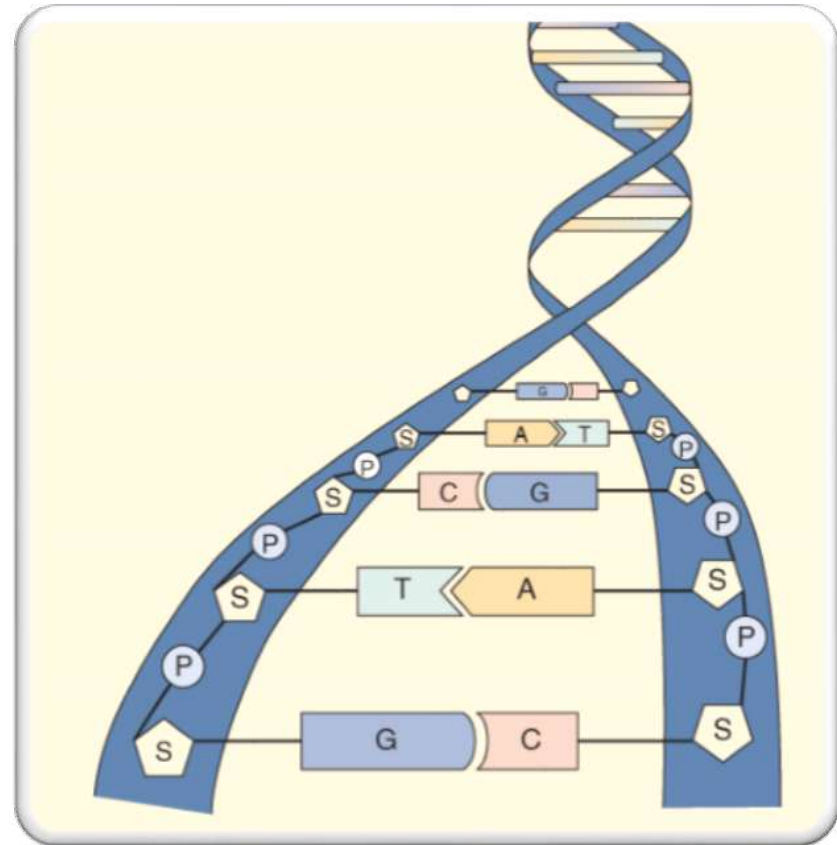
DNA

- DNA is a large molecule made by links of a series of repeating units called nucleotides.
- A nucleotide is composed of a sugar, a phosphorus-containing group, and a nitrogen-containing base.



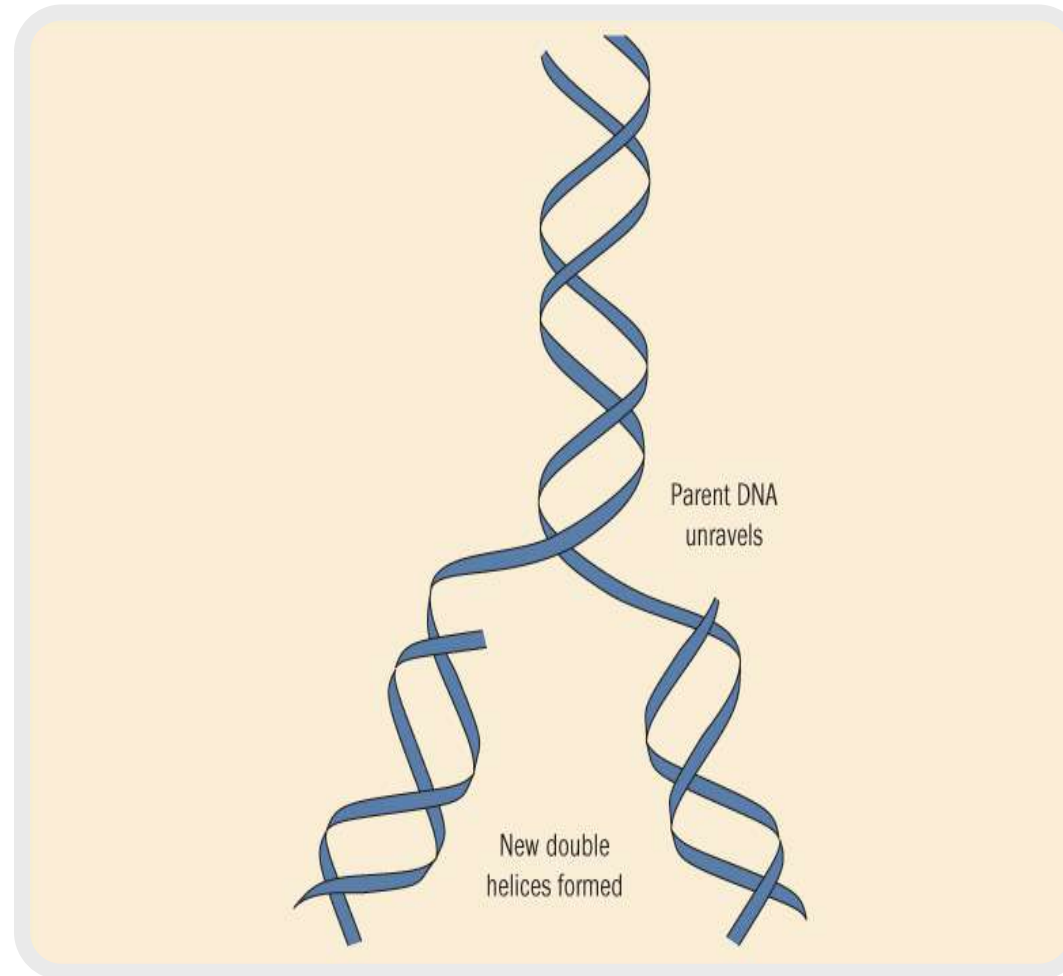
DNA

- Four types of bases are associated with the DNA structure:
 - *Adenine (A)*
 - *Guanine (G)*
 - *Cytosine (C)*
 - *Thymine (T)*
- Bases pair adenine to thymine and guanine to cytosine.
- The bases are aligned in a double-helix configuration.
- The order of the bases is what distinguishes different DNA strands.



DNA

- DNA Replication
 - DNA copies itself prior to cell division
 - DNA replication begins with the unwinding of the DNA strands of the double helix

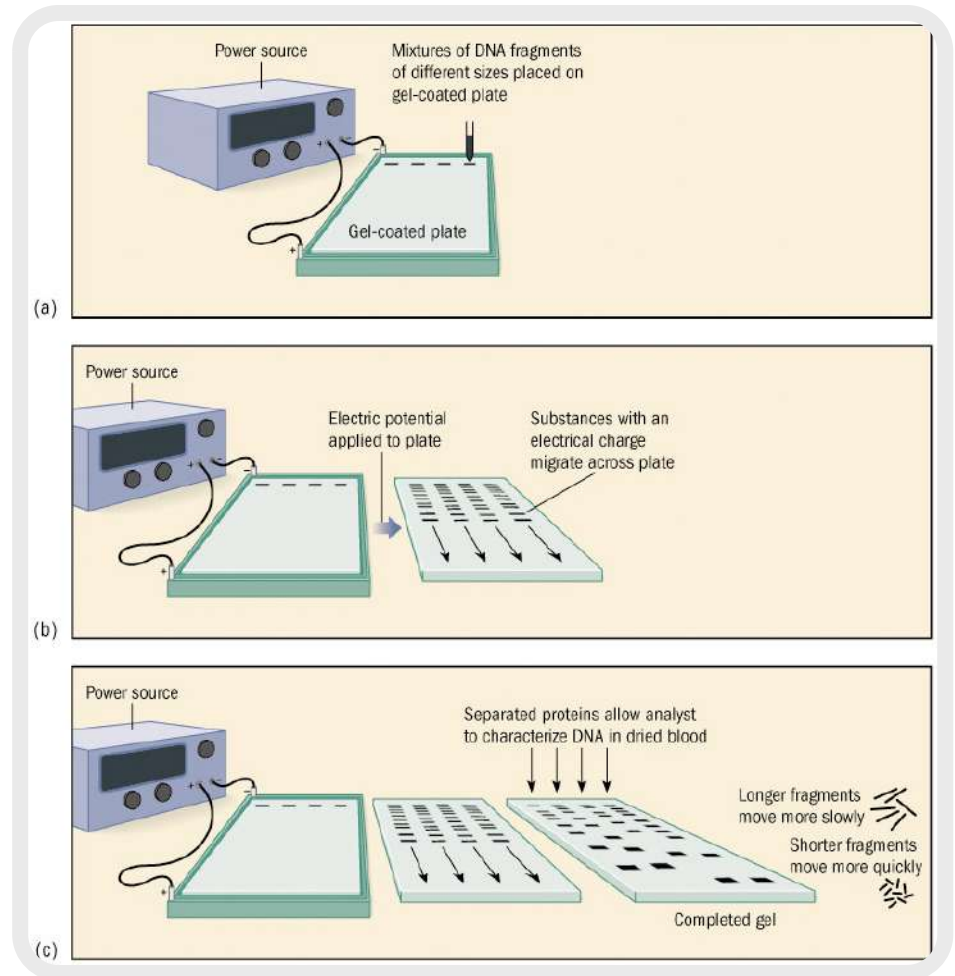


DNA Typing

- Portions of the DNA molecule contain sequences of bases that are repeated numerous times, known as tandem repeats
- These tandem repeats offer a means of distinguishing one individual from another through DNA typing.
- Length differences associated with repeating DNA strands are called restriction fragment length polymorphisms (RFLP) and form the basis for DNA typing.
- Restriction enzymes “cut” the DNA into pieces based on these repeating segments.

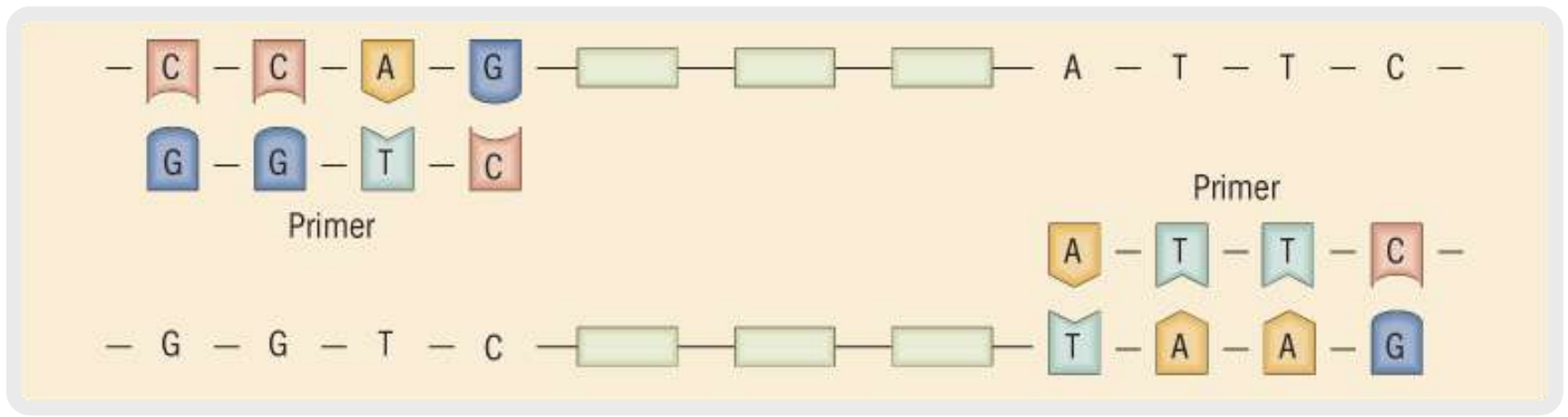
DNA Typing

- Electrophoresis forces separated pieces of DNA across a gel-coated plate under the influence of an electrical potential.
- Smaller DNA fragments move at a faster rate than the larger ones
- When comparing the DNA fragment patterns of two or more specimens, one merely looks for a match between the band sets.



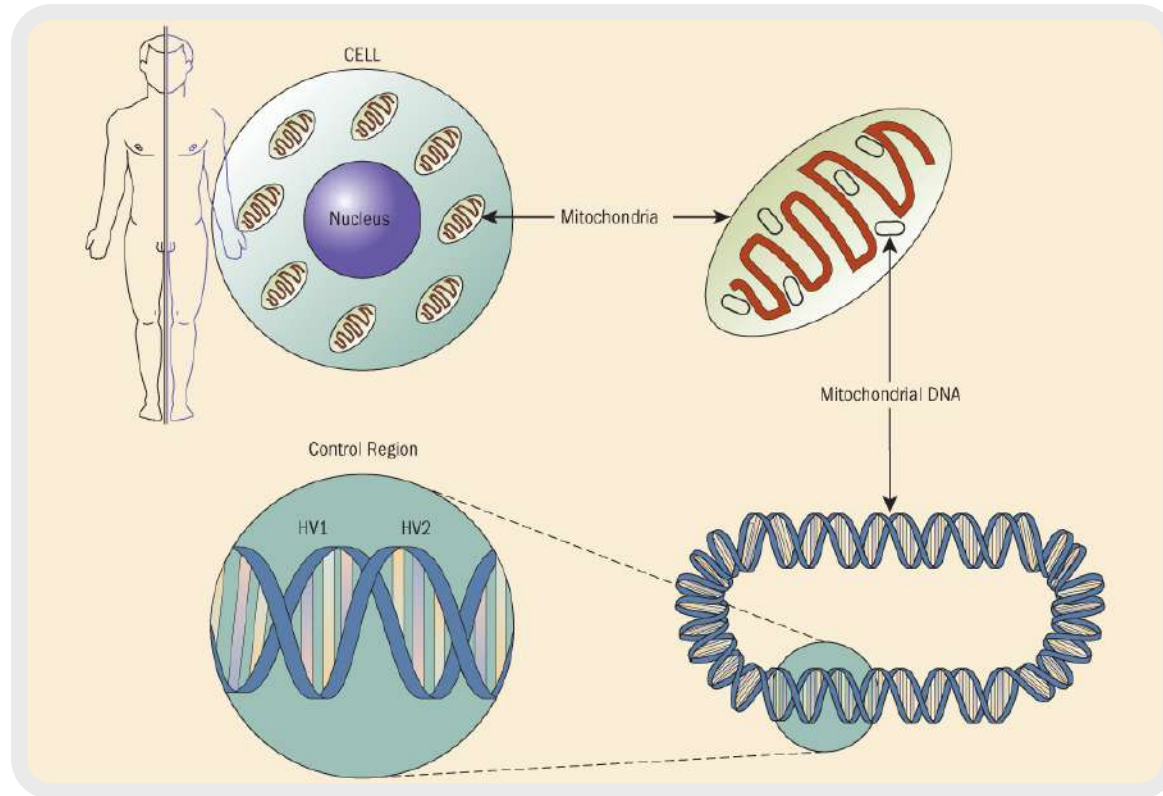
PCR Testing

- DNA is heated to separate it
- Primers (short strands of DNA used to target specific regions of DNA for replication) are added, which hybridize with the strands
- DNA polymerase and free nucleotides are added to rebuild each of the separated strands
- Best used when the sample is small.



Mitochondrial DNA Testing

- mDNA is located in the mitochondria of cells.
- mDNA is inherited strictly from the mother.
- mDNA analysis is more rigorous, time consuming, and costly when compared to nuclear DNA analysis



CODIS

- Combined DNA Index System
- Computer software developed by the FBI that maintains local, state, and national databases of DNA profiles from convicted offenders, unsolved crime scene evidence, and profiles of missing person.
- Currently contains about 470,000 profiles from unsolved cases.

Collection of DNA Evidence

- Blood
- Semen
- Saliva
- Skin cells
- Hair
- Bone

Collection of DNA Evidence

- Clothing from victim and suspect with blood evidence must be collected
- Dried blood is best removed from a surface using a sterile cotton swab lightly moistened with distilled water that is air dried before placed in a swab box, and then in a paper or manila envelope.
- Standard/reference DNA specimens must also be collected with a buccal swab (swab of the cheek).
- Packaging of biological evidence in plastic or airtight containers must be avoided because the accumulation of residual moisture could contribute to the growth of DNA-destroying bacteria and fungi.

Other Serological Evidence

- Semen, or seminal fluid, is produced by the male reproductive organs.
 - If spermatozoa are present, DNA testing can be done.
 - Spermatozoa may not be present if the perpetrator has a low sperm count or has had a vasectomy.
- Saliva can be determined by testing for an enzyme called amylase. Amylase breaks down starch to begin digestion.
 - Saliva can be tested to determine the presence of trace amounts of drugs in a body.

Immunoassay Techniques

- When a stain is encountered at a crime scene that appears to be blood, there are several questions:
 1. Is it blood?
 2. If it is blood, is it human or some other species?
 3. If it is human, can it be linked to a particular individual?
- Is it blood?
 - Screening test for blood – spray area with Luminol.
 - Luminol reacts with iron from the hemoglobin of blood causing a faint blue fluorescence.
 - Works on even tiny amounts of blood
 - Works on diluted samples of blood (up to 300,000 times dilute)
 - Does not interfere with subsequent DNA analysis that may be done
 - May destroy other components for testing.

Immunoassay Techniques

Luminol



Immunoassay Techniques (cont)

- Is it blood? (cont)
 - Kastle-Meyer Color Test – uses a solution of phenolphthalein and hydrogen peroxide on a piece of filter paper to detect blood.
 - Paper turns pink when exposed to blood
- If it is blood, is it human?
 - Precipitin test will distinguish human blood from blood of other species.
 - Precipitin is an antibody that reacts with its corresponding antigen in human blood.
 - If the blood sample clots, then the blood must be human.
 - Once determined to be human, DNA evidence may be able to link the blood to a specific individual.
 - Blood can also be tested for the presence of drugs or alcohol.

CASE STUDY: Lindy Chamberlain

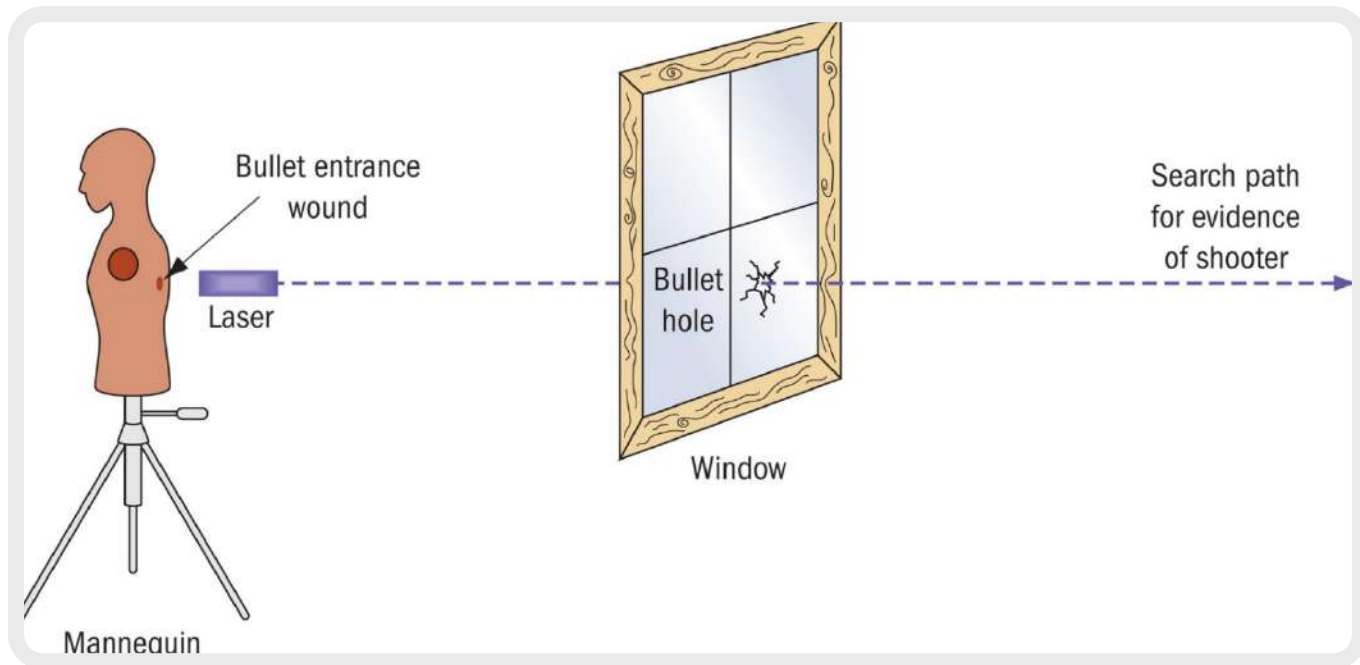
- <http://lindychamberlain.com/legal-process-and-findings/forensic/>

Blood Stain Patterns

- Using concepts from Biology and Physics, investigators are able to discern a lot about a crime scene just by observing any blood that is present.
- Patterns of drops, pools, or smears of blood provide crucial information about the sequence of the crime as well as the weapon used and possible identifying information about the perpetrator.
- For example, blood spatter patterns can reveal the origin of the attack, distance from the target, direction of the force, position of the persons involved, movement of persons involved, and number of blows or shots. Blood spatter can be used to reconstruct a crime scene to verify statements from witnesses, victims, or suspects.

Crime Scene Reconstruction

- Recovery of physical evidence can be used to sort out the events surrounding the crime.
- Example: A laser is used to determine the search area for the position of a shooter who fired a bullet through a window and wounded a victim.



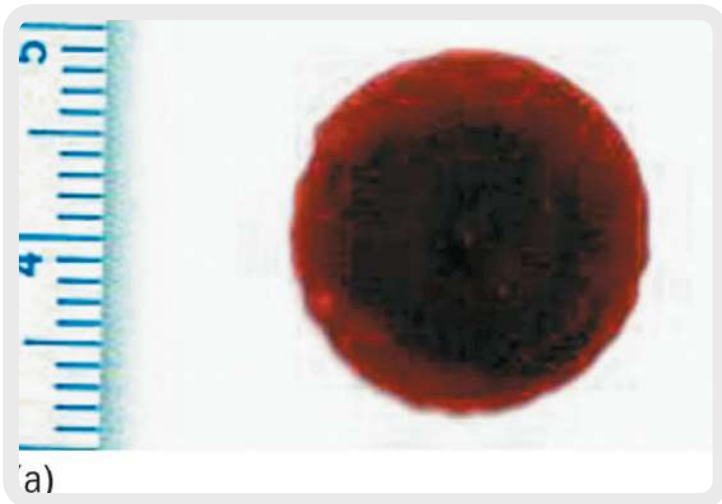
Bloodstain Features

- Bloodstain pattern interpretation may uncover;
 - The direction from which the blood originated
 - The angle at which a blood droplet struck a surface
 - The location or position of a victim at the time a bloody wound was inflicted.
 - The movement of a bleeding individual at the crime scene
 - The approximate number of blows that struck a bleeding victim
 - The approximate location of an individual delivering blows that produced a bloodstain pattern.

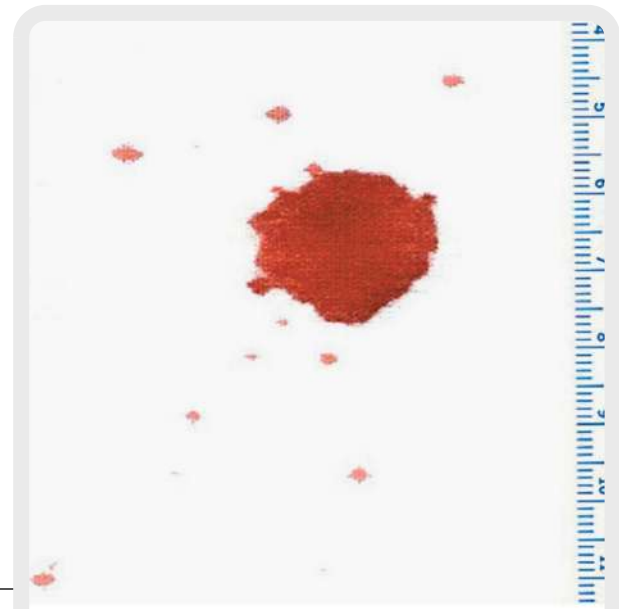
Bloodstains

Surface texture is of paramount importance. In general, the harder and less porous the surface, the less spatter results.

Bloodstain from a single drop that struck a glass surface after falling 24 inches

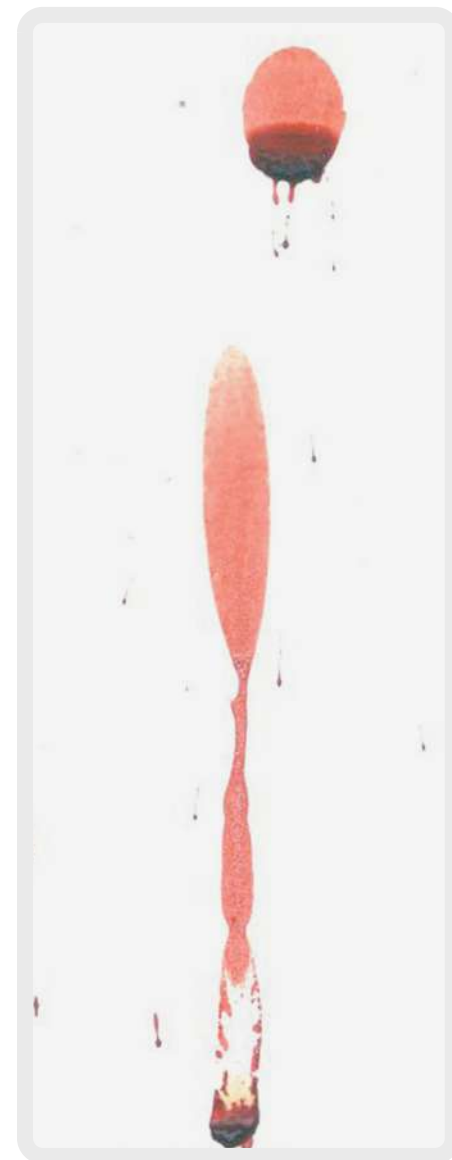


Bloodstain from a single drop that struck a cotton muslin sheet after falling 24 inches



Directionality and Angle of Impact

- The angle of impacts of blood on a flat surface can be determined by measuring the degree of circular distortion.
- At right angles, the blood is circular; as the angle decreases, the stain becomes elongated.
- The higher pattern is of a single drop of human blood that fell 24 inches and struck hard, smooth cardboard at 50°.
- The lower pattern is of a single drop of human blood that fell 24 inches and struck hard, smooth cardboard at 15°. The tail shows the direction

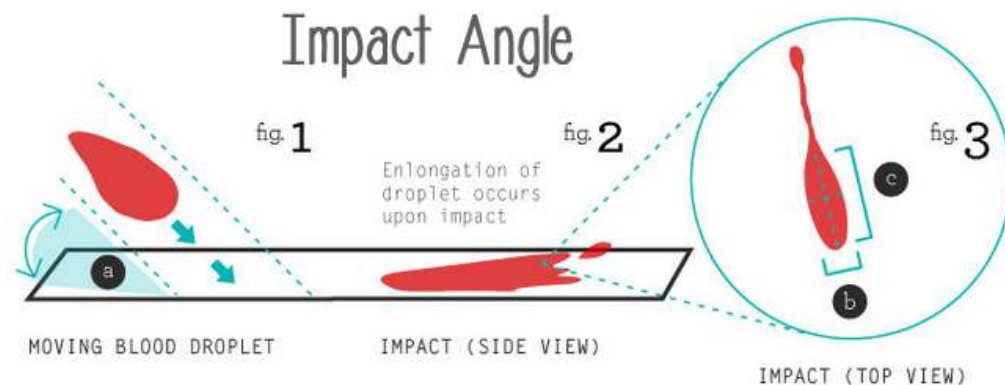


Directionality and Angle of Impact

- Mathematically, the angle of impact can be calculated by the equation and determining the inverse of Sine A:

$$\sin A = \frac{\text{Width of Blood Stain}}{\text{Length of Blood Stain}}$$

- The impact angle of blood on a flat surface can be determined by measuring the degree of circular distortion.
- At right angles, the blood drop is circular; as the angle decreases, the stain becomes elongated.



Angle of Impact (cont)

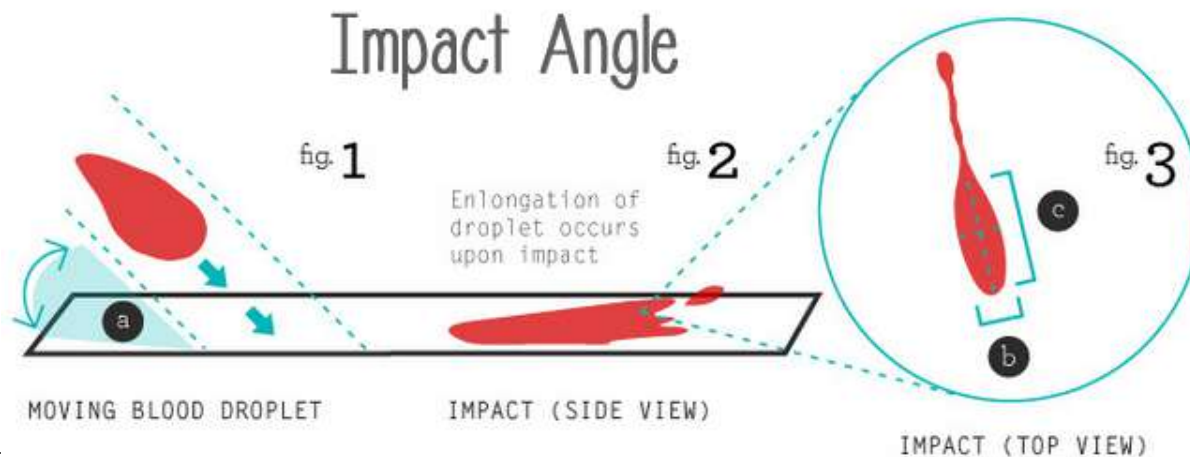
- Calculating angle of impact: ratio between the length and the width of a blood drop is the function of the sine of the angle of impact.

$$\sin(\alpha) = w / l$$

$\sin(\alpha)$ is the angle of impact

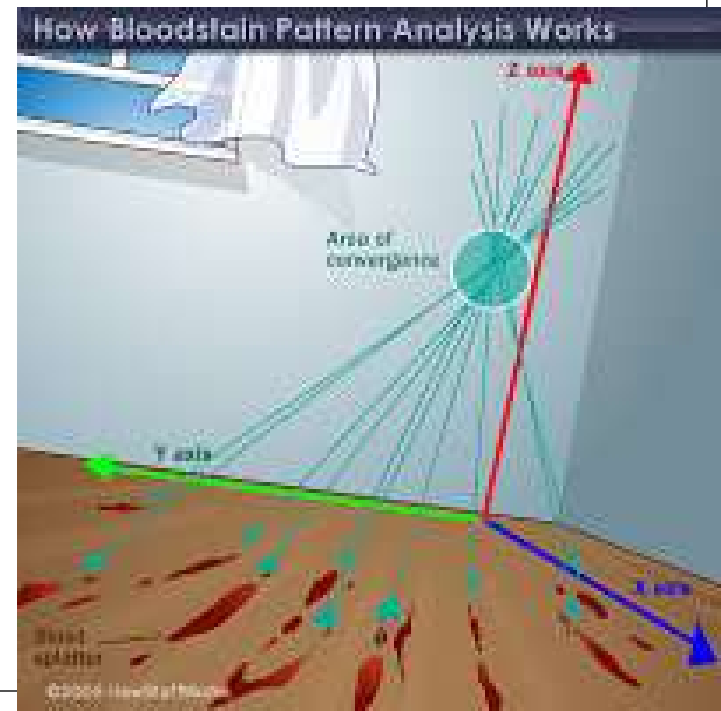
w is the width of the bloodstain

l is the length of the bloodstain.



Angle of Impact

- By connecting a line of string from the point of origin to the blood spatter, an investigator can use a protractor to determine the angle of impact.
- The angle of impact can be estimated reproducing spatter patterns at various angles and observing the outcome.
- When a drop of blood falls, it forms a spherical shape. When it hits a surface, the drop leaves a bloodstain of varying elliptical degrees that can indicate the angle of impact.



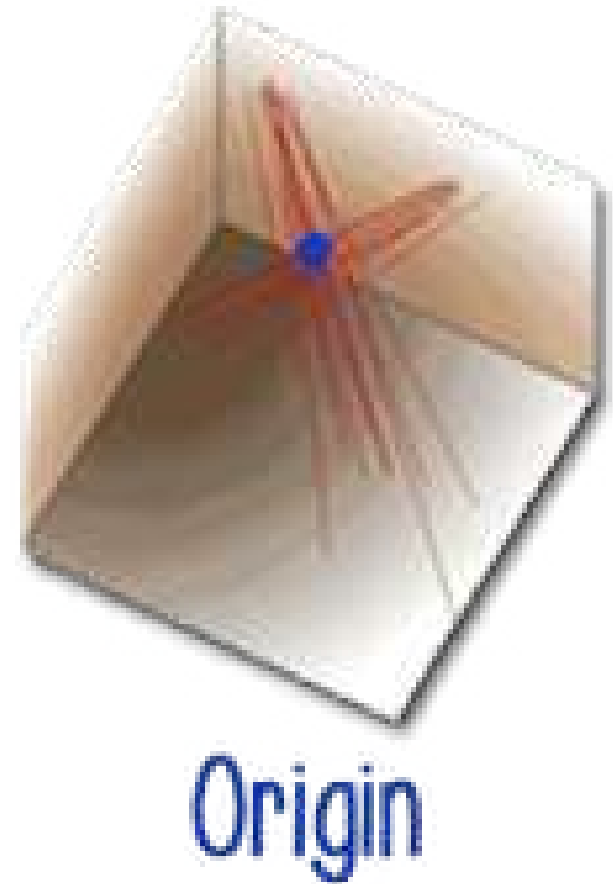
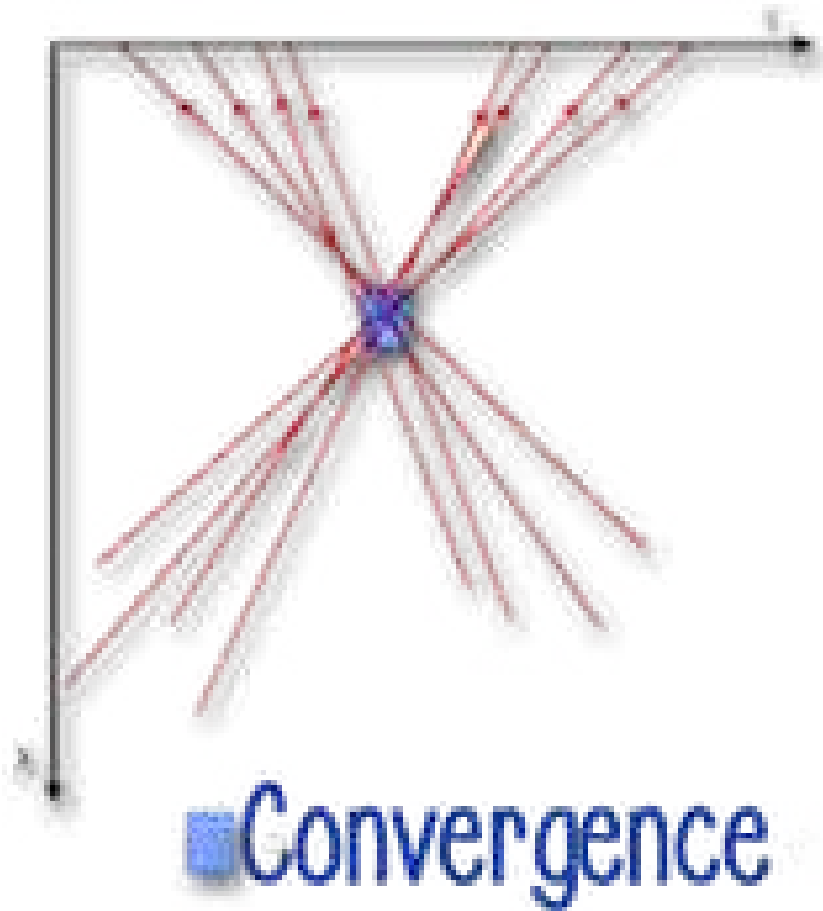
Angle of Impact (cont)

- Calculating angle of impact: Examples
- Let us say that the width is 9mm and the length is 18mm.
STEP 1: $\sin^{-1}(9\text{mm}/18\text{mm}) = 30^\circ$
The angle of impact was 30° .
- Let us say that the width is 1.5cm and the length is 3.0cm.
STEP 1: $\sin^{-1}(1.5\text{cm}/3.0\text{cm}) = 30^\circ$
The angle of impact was 30° .
- When calculating the angle of impact it is important to keep in mind that (\sin^{-1}) does not mean $(1/\sin)$. Instead, it means the inverse sin function. When dividing we make sure to divide the smaller number by the larger number to get a number less than one.

Point of Convergence and Point of Origin

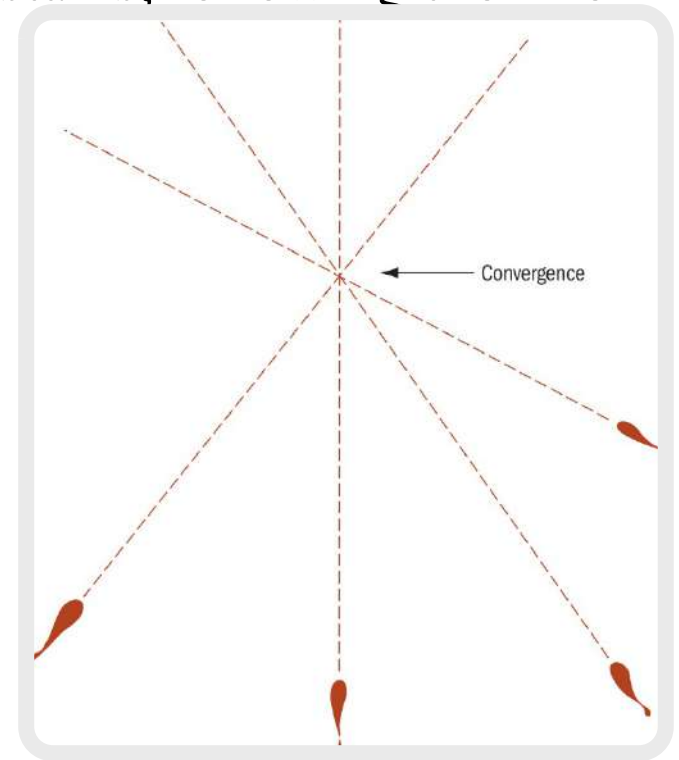
- Point of convergence – starting point of the bloodshed event.
 - Determined by creating intersecting lines through blood drops to identify where all the lines intersect.
 - Shows the origin and direction from which the blood was traveling.
- Point of origin – where the suspect and victim were and possibly how they were positioned during the bloodshed event.
 - Adds a third dimension to the scene.
 - Determined using protractors and elastic strings to show the angle and direction in which the blood traveled across the crime scene.
 - Intersection of the strings helps determine the location of the persons and angle of impact

Point of Convergence and Point of Origin (cont)



Area of Convergence

- The area of convergence is the point on a two-dimensional plane from which the drops in an impact pattern originated.
- This can be established by drawing straight lines through the long axis of several individual bloodstains, following the line of their tails.



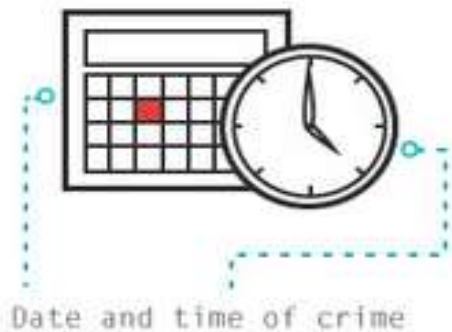
Area of Origin

- The area of origin of an impact bloodstain pattern is the area in a three-dimensional space from which the blood was projected.
- This will show the position of the victim or suspect in space when the stain-producing event took place.
- The string method is commonly used at a crime scene to approximate the position of the area of origin using found angles of impact of individual stains in the pattern.

Blood Pattern Analysis

WHAT BPA CAN DETERMINE

fig. 1



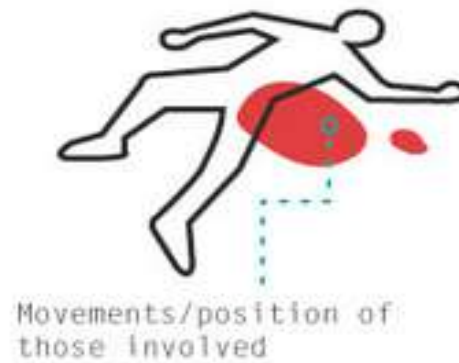
Date and time of crime

fig. 2



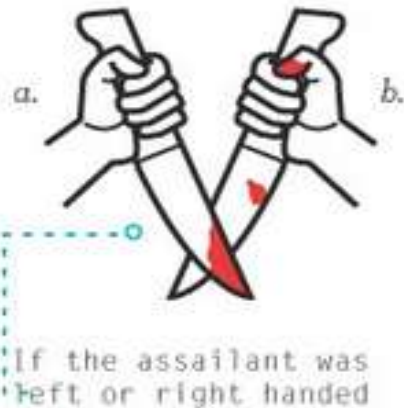
Type and velocity of weapon

fig. 3



Movements/position of those involved

fig. 4



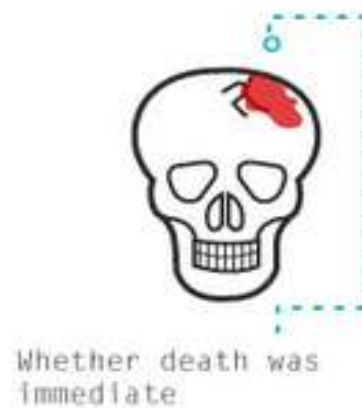
If the assailant was left or right handed

fig. 5



Types of injuries dealt

fig. 6



Whether death was immediate

Impact Bloodstain Spatter Patterns

- Impact spatter occurs when an object impacts a source of blood.
- Forward spatter is projected outward and away from the source
- Back spatter, also known as blow-back spatter, is projects backward from the source.
- The direction of travel of blood striking an object may be discerned because the pointed end of a bloodstain always faces its direction of travel

Classifying Impact Spatter

- Using droplet size to classify impact patterns by velocity gives investigators insights into the general nature of a crime but cannot illuminate the specific events that produced the spatter pattern.
- Low Velocity Spatter
 - Drops with diameters of 4mm or more normally produced by an applied force of up to 5 ft/sec.
- Medium Velocity Spatter
 - Drops with diameters of 1-4 mm with an applied force of 5 to 25 ft/sec
- High Velocity Spatter
 - Drops with diameters of less than 1mm from an applied force of 100ft/sec or faster.

Sources of Blood Spatter

- Impact Spatter
- Cast-off Spatter
- Arterial Spray Spatter



Gunshot Spatter

- Gunshot spatter is fine forward spatter from an exit wound and back spatter from an entrance wound.
- The gunshot produces only back spatter if the bullet does not exit the body.
- Depending upon the distance from the victim that the gun was discharged, some back spatter may strike the gunman and enter the gun muzzle. This is call the drawback effect.

Cast-off Spatter

- A cast off pattern is created when a blood-covered object flings blood in an arc onto a nearby surface.
- This kind of pattern is commonly produced by a bloody fist or weapon between delivering blows.
- The features of the cast off pattern are affected by the size of the object, the amount of blood, and the direction the object was moving.
- By counting and pairing forward/backward patterns, one may determine the minimum number of blows delivered.

Arterial Spray Spatter

- Arterial spray spatter is caused by an injury to the heart or a main artery and the pressure of the continued pumping.
- The site of the initial injury to the artery can be found where the pattern begins with the biggest spurt.
- The trail away from this point shows the victim's movement.
- The oxygenated blood spurting from the artery tends to be a brighter red color than blood expelled from impact wounds.



Expired Blood Patterns

- An expired blood pattern is created by blood that is expelled from the mouth or nose from an internal injury.
- The presence of bubbles or oxygen in the drying drops, or a lighter color as a result of dilution by saliva, can differentiate a pattern created by expiration blood.
- The presence of expired blood gives an important clue as to the injuries suffered and the events that took place at a crime scene.

Void Patterns

- A void is created when an object blocks the deposition of blood spatter onto a target surface or object, and the spatter is deposited onto the object or person instead.
- The blank space on the surface or object may give a clue as to the size and shape of the missing object or person.
- Voids may be applicable for establishing the body position of the victim or assailant at the time of the incident.

Contact/Transfer Patterns

- A contact or transfer pattern is created when an object with blood on it touches one that does not have blood on it.
- Simple transfer patterns are produced when the object makes contact with the surface and is removed without any movement of the object.
- The size and general shape of the object may be seen in a simple transfer
- Other transfers, known as swipe patterns, may be caused by movement of the bloody object across a surface.



Flows

- Flow patterns are made by drops or large amounts of blood flowing by the pull of gravity.
- The flow direction may show movements of objects or bodies while the flow was still in progress or after the blood dried.
- Interruption of a flow pattern may indicate the sequence and passage of time between the flow and its interruption.

Pools

- A pool of blood occurs when blood collects in a level (not sloped) and undisturbed place.
- Blood that pools on an absorbent surface may be absorbed throughout the surface and diffuse, creating a pattern larger than the original pool.
- Considering the drying time of a blood pool can yield information about the timing of events that accompanied the incident.

Skeletonization

- The phenomenon of skeletonization occurs when the edges of a stain dry to the surface.
- This usually occurs within 50 seconds of deposition of droplets, and longer for larger volumes of blood.
- After this time, if the bloodstain is altered through contact of a wiping motion, the skeletonized perimeter will be left intact.
- Knowing the skeletonization time, an investigator determines the timing of movement or activity.

Drop Tail Patterns

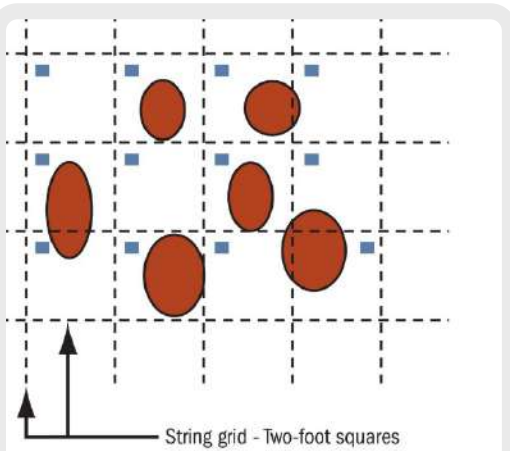
- The pattern may show direction and speed of movement, lead to a discarded weapon, or provide identification of the suspect by his or her own blood.

Bloodstain Pattern Analysis

- See handout
- Use pdf version to access links.

Documenting Bloodstain Evidence

- Investigators should note, study, and photograph each pattern and drop to record the location of specific patterns accurately and to distinguish the stains from which laboratory samples were taken.
 - Grid Method – a grid of squares of known dimensions are set up over the entire pattern.
 - Perimeter Ruler Method – a rectangular border of rulers is set up around each pattern and a smaller ruler is placed next to each stain.



More info on Bloodstain Patterns

- <http://www.slideshare.net/lexakay/bloodstain-pattern-recognition>
- <http://science.howstuffworks.com/bloodstain-pattern-analysis.htm>
- <http://www.crime-scene-investigator.net/simplified-guide-to-bloodstain-pattern-analysis.html>

Forensic Serology Review Answer

What blood types are possible from these parents:

1. Mom – AB Dad – AB

AB, A, B

2. Mom – AB Dad – O

A, B

3. Mom – B Dad – B

B, O

4. Mom – A Dad – O

A, O

Forensic Serology Review

- Match the definitions to the correct term

Definition	term
The science that deals with the properties and reactions of serums, especially blood serum.	Genes
A substance that stimulates the immune system to manufacture antibodies (immunoglobulins).	Alleles
Any of various proteins produced in the blood in response to the presence of an antigen.	Antigens
A hereditary unit consisting of a sequence of DNA that occupies a specific location on a chromosome and determines a particular characteristic in an organism.	Serology
One of two or more alternative forms of a gene at the same site in a chromosome, which determine alternative characters in inheritance.	Antibodies

Forensic Serology Review Answers

- Match the definitions to the correct term

Definition	term
The science that deals with the properties and reactions of serums, especially blood serum.	Serology
A substance that stimulates the immune system to manufacture antibodies (immunoglobulins).	Antigens
Any of various proteins produced in the blood in response to the presence of an antigen.	Antibodies
A hereditary unit consisting of a sequence of DNA that occupies a specific location on a chromosome and determines a particular characteristic in an organism.	Gene
One of two or more alternative forms of a gene at the same site in a chromosome, which determine alternative characters in inheritance.	Alleles

Forensic Serology Review

- Match the definitions to the correct term

Definition	term
An organism's genetic makeup	Presumptive Testing
The observable physical or biochemical characteristics of an organism, as determined by both genetic makeup and environmental influences.	Genotype
Also known as preliminary tests, screening tests or field tests	Kastle-Meyer Color Test
A presumptive test used to detect if a substance is blood. It works using phenolphthalein which turns pink in the presence of blood.	Phenotype
An antibody in blood that combines with an antigen to form a solid that separates from the rest of the blood.	Precipitin

Forensic Serology Review Answers

- Match the definitions to the correct term

Definition	term
An organism's genetic makeup	Genotype
The observable physical or biochemical characteristics of an organism, as determined by both genetic makeup and environmental influences.	Phenotype
Also known as preliminary tests, screening tests or field tests	Presumptive Testing
A presumptive test used to detect if a substance is blood. It works using phenolphthalein which turns pink in the presence of blood.	Kastle-Meyer Color Test
An antibody in blood that combines with an antigen to form a solid that separates from the rest of the blood.	Precipitin

Forensic Serology Review

- Match the definitions to the correct term

Definition	term
A component of blood which is one of the body's defenses against disease. This where DNA is gathered from blood samples.	Plasma
The liquid part of blood that is 92% water.	Luminol
Conclusively identifies the identity of a biological material	Confirmatory Testing
This compound gives a strong blue fluorescence when viewed with a UV light in the presence of blood or blood residue even when very diluted.	Agglutination
The clumping together of red blood cells or bacteria, usually in response to a particular antibody	White Blood Cells

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An enzyme that breaks down starch and helps the body begin to break down food which can be tested for and used to determine if a sample is saliva.	Expired Blood
This bloodstain occurs when blood is transferred from a bloody object to a previously unstained surface	Wipe
Occurs when a bloodstain is removed or altered because a non-bloody object has moved through a wet blood stain.	Swipe
A blood pattern in which a weapon or object swings in an arc and deposits blood on a surface in the path of that arc.	Cast-off
Blood that exits the body after an internal injury through the nose or mouth in the process of breathing or coughing.	Amylase

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