Forensic Serology

- Serology - examination of body fluids
  - Analysis of blood
  - Identification of other fluids and stains
  - Analysis of bloodstain patterns
- Serological evidence is not as powerful as DNA evidence and cannot *individualize* blood to a particular person
Blood

- A solution of various materials in water
- Liquid portion of blood - Plasma
  - 55% of blood volume
  - Contains proteins, carbohydrates, fats, salts, minerals and antibodies
- Solid portion of blood
  - Remaining 45% of blood
  - made up of red blood cells, white blood cells, and platelets
Blood

- Red blood cells (erythrocytes)
  - formed in blood marrow
  - transport oxygen to cells
  - remove carbon dioxide from cells

- White blood cells (leukocytes)
  - formed in lymph nodes
  - part of immune system – fight infection

- Platelets (thrombocytes)
  - major part of clotting process
Forensic Analysis of Blood

- Purpose: to determine source of blood
- May be in multiple locations
- May be degraded or purified
- Is a perishable biological material
- Failure to collect and preserve it may result in spoilage, inability to analyze it, or inadmissibility of results in court
Preliminary Considerations

- Validated protocols must be followed
  - Careful physical examination of item for serology evidence
  - Photograph and videotape at exact location
  - Preliminary screening tests – presumptive tests
  - Confirmatory tests for chemical identity of substance
Detecting Blood

- Two major chemical tests for presence of blood use *luminol* and *fluorescein*
  - Luminol- reacts in presence of heme part of hemoglobin and undergoes chemiluminescence

![Blood on ground](Blood on ground)

![Shoeprint visible with luminol](Shoeprint visible with luminol)
Detecting Blood

- Fluorescein undergoes fluorescence and a strong short light wave is used to induce fluorescence. Also includes a thickening agent that allows it to cling to vertical surfaces
Confirmatory Tests for Blood

- Two most popular laboratory tests for confirmation of blood are
  - Teichmann test (photo A)
  - Takayama test (photo B)
- Both are microcrystal tests
- Shaped crystals form by reaction between reagent and heme of blood
Species Determination Tests

- This is blood, but is it human or animal?
- Immunoprecipitation lab tests determine if it is human
  - Precipitin Ring Test
  - Ouchterlony Double Diffusion Test
- Use animal blood (usually rabbit) that has anti-human antibodies (a protein made by the host’s immune system as a reaction to the introduction of a specific antigen)
- Rabbit blood is antiserum for human antigens (a molecule that is part of the immune system)
- Rabbit antisera is added to test sample of human blood to determine whether there is a reaction between anti-human antibodies and human antigens in blood
Species Determination Tests

- Precipitin Ring Test
- Ouchterlony Double Diffusion Test

1. rabbit antiserum
2. positive precipitin reaction
3. positive precipitin reaction
4. rabbit antiserum
5. positive precipitin reaction
Field Tests For Blood

- Kastle-Meyer Test (presumptive or screening)
  - A test to determine if substance IS blood or NOT
  - Phenolphthalein (color indicator)
  - Hydrogen peroxide (combines with heme in blood)
  - Positive test is vivid fuchsia color
Field Tests For Blood

- Hexigon OBTI Test
  - A test to determine if blood is human or animal
  - Similar to a home pregnancy test strip
  - Absorbent strip contains blue particles and monoclonal anti-human hemoglobin antibodies
  - Control indicator (C) blue stripe indicated a valid test
  - Test indicator (T) blue stripe if sample is human
  - Test indicator (T) no blue stripe if sample is animal
Genetic Markers in Blood

- Not all human blood is the same
- Most familiar of blood group systems—ABO
- 4 subgroups in ABO system: A, B, AB and O
- Each subgroup is characterized by presence of certain *antigens* on surface of red blood cells
- *Agglutination* occurs when *antibodies* and *antigens* come together
A Model of the ABO Group

Type A
A Antigens
Anti-B Antibodies

Type B
B Antigens
Anti-A Antibodies

Type AB
A & B Antigens
No Antibodies

Type O
No Antigens
Anti-A & Anti-B Antibodies
Properties of the ABO Group

• Agglutination of red blood cells occurs when two non-compatible types are mixed

Normal Human Blood Cells

Agglutinated Human Blood Cells
Other Blood Groups

- Rh system (Rh factor): an antigen on human red blood cells
  - Possess factor—Rh⁺
  - Missing factor—Rh⁻
  - Examples: AB⁺ or AB⁻, B⁺ or A⁻
- Lewis system
- MN system
Blood Enzyme Markers

- *Polymorphic enzymes* are enzymes found in human blood
- Enzymes survive drying process and are forensically useful as evidence
- Rarely used anymore, as DNA typing is much more specific
Other Biological Fluids and Stains

- Seminal fluid
- Vaginal secretion
- Saliva
- All may be found in criminal sexual conduct (CSC) crimes
- All are critical as physical evidence
Seminal Fluid

• Is a mixture of cells, sperm and a variety of organic and inorganic materials
• Produced in males in seminal vesicles, prostate and Cowper’s glands
• Some males have low sperm counts (oligospermic) or no sperm (aspermic)
• Seminal fluid contains large concentrations of seminal acid phosphatase
Preliminary Tests for Semen

• Presence of Seminal Acid Phosphatase (SAP) considered to be *presumptive*
• Brentamine Fast Blue B reagent is major test for seminal fluid
• This test is carcinogenic and must be handled with care
Confirmatory Tests for Semen

• Mixing the dyes: Picroindigocarmine (PIC) and Nuclear Fast Red (Christmas tree stain) give visual confirmation of the presence of sperm.

• Seminal fluid may be confirmed if stain reacts positively for presence of seminal acid phosphatase and is PSA is identified.

• Prostrate-specific Antigen (PSA) is secreted into semen by prostate gland and can be detected using antibody-antigen test.
Vaginal Secretions

• Important when foreign object has been inserted into vagina

• Major test for vaginal secretions is to identify glycogenated epithelial cells

• Cells are formed during menstruation and quantity depends on what stage of menstrual cycle female is in (ovulation produces highest concentrations of cells)

• periodic acid-Schiff reagent is used to test for presence of cells
Saliva

- Produced in mouth for preliminary digestion of food
- Consists of water, proteins, enzymes and salts
- No specific test for saliva
- *Alpha-amylase test* is generally accepted test for saliva
- Amylase found in highest concentrations in saliva
Bloodstain Pattern Analysis

• Provides understanding of what happened in violent crime
• Assists in reconstructing incident
• Can be used to provide evidence or exonerate suspect
Physical Properties of Blood

- Blood has a fairly high surface tension
- Blood is very viscous (flows more slowly than water)
- Blood tends to adhere to external surface
- Blood that falls from body will form a sphere (not a teardrop as is commonly depicted)
Physical Properties of Blood

- Size of spherical blood droplet depends upon size of surface from which it falls (larger surface, more volume, larger droplet)
- Height of fall changes diameter of blood drop (closer to ground, smaller diameter)
- Blood reaches terminal velocity (highest speed) at approximately 7 feet and diameter will not increase
Physical Properties of Blood

- *Spines*—protrusions from the parent blood drop
- *Satellite spatter*—smaller droplets that leave parent drop and land near it
- Disruption of surface tension and cohesive properties of blood due to type of target surface
Mathematics of Bloodstains

- Blood cast onto a surface at an angle has an elliptical shape.

- Angle of impact is determined by measuring length and width of stain, and inverse sine of ratio of width to length is equal to angle of impact.

\[
\theta = \arcsin\left(\frac{\text{width}}{\text{length}}\right)
\]

\(\text{(Impact Angle)}\)
Measure only the round part of the stain—not the spines.

Measure only the ellipse of the stain—not the tail.

Mathematics of Bloodstains

- Measuring width and length of bloodstains to determine impact angle.
Typical Blood Shapes At Various Impact Angles

10°  20°  30°  40°  50°

60°  70°  80°  90°
Mathematics of Bloodstains

• In a number of bloodstains, *Area of Convergence* can be determined by drawing lines from leading edge of stains through the long axis

• Area of Convergence helps to locate the origin of the bloodstain
Using Area of Convergence To Find Point of Origin
Bloodstain Pattern Categories

• *Passive stains* move only under influence of gravity
• *Spatter stains* arise from a force in addition to gravity
• *Altered stains* are physically or physiologically changed
Passive Bloodstains

- Vertical drips
- Large volume
  - Large amount of blood hits target at one time
- Flow
  - Natural movement of large blood deposit
- Swipe
  - Bloodied object leaves a motion transfer of blood

Prints (shoe, hand, hair, etc)
Spatter Bloodstains

- **Impact Spatter Due to Blunt Force** - result of bloodied object receiving a blow
- Must have blood on surface to create this type of pattern
- First blow does not generally produce impact stain, with exception of gunshots
- Bloodstains are typically 1-4 mm in size
Spatter Bloodstains

- **Impact Spatter Due to Gunshot**
  - Bloodstains <1mm in length
  - Misty appearance

- **Cast Off**
  - Linear pattern of blood leaving weapon such as knife, bat, or hand

Impact Due to Gunshot

Simulating a Cast Off Pattern
Spatter Bloodstains

- *Arterial*
  - Large amount of blood under pressure
  - Arc pattern
  - Due to breach of major artery (carotid, femoral)

- *Expirated*
  - Blood ejected with force from respiratory system
  - Similar pattern to impact spatter, but may contain air bubbles
Altered Bloodstains

• Physiologically Altered Stains
  • *Insect activity*—trails
  • *Addition of foreign* (non-blood) *material*

• Physically Altered Stains
  • *Void*—absence of blood where it should be
  • *Wipe*—existing bloodstain altered by secondary motion through it