Introduction to Forensic Science

Forensic Serology

I. Forensic Serology

A. Definition – the identification and classification of blood, semen and other body fluids to determine the identity of a suspect or victim
   1. Serology comes from the Sanskrit "sara" which means "to flow"
   2. Serology - a science dealing with serums and especially their reactions and properties.

B. History of Serology
   1. 1628 the English physician William Harvey discovers that blood circulates throughout the body
   2. 1930 - Karl Landsteiner – discovered that all blood is not the same, there are different types (Landsteiner received the Nobel Prize for his work on serology.)
      a. Type A - 40%
      b. Type B - 11%
      c. Type O - 45%
      d. Type AB - 4%
   3. 1940- Landsteiner discovers Rh factor in blood
      a. These findings are of utmost importance for blood transfusions between types - these results in immediate death.
      b. Rh is taken from the word Rhesus. The blood of Rhesus monkeys was studied to learn more about this factor.
      c. Rh disease can result in severe anemia, jaundice, brain damage, and heart failure in a newborn
      d. 85% of people are Rh positive
      e. If a Rh-negative woman and a Rh-positive man conceive a child, there is the possibility that the newborn's blood will be incompatible with the mother. There are now ways to treat and prevent these problems thanks to the research of Landsteiner.

II. The Nature of Blood

A. Antigens – usually protein or carbohydrate substances (as toxins or enzymes) capable of stimulating an immune response
   1. The Kell antigen is confined to the Caucasian population
   2. The Duffy antigen is completely absent from the Caucasian population.
   3. Blood grouping characteristics can be used to determine the race of a suspect or to preclude a suspect from further consideration

B. Antibodies - any of a large number of proteins of high molecular weight that are produced normally by specialized B cells after stimulation by an antigen and
act specifically against the antigen in an immune response

C. Plasma – the fluid portion of blood. Plasma is mainly water (55%) and red and white blood cells, and platelets.

D. Blood Clot – this occurs when red blood cells are trapped by fibrin, a protein found in plasma

E. Serum – blood from which the fibrin and suspended material (as cells) have been removed

F. Blood Typing – for every antigen there is a specific antibody. The presence or absence of the A and B antigens on the red blood cells establishes a person’s blood type.
   1. Blood typing determines a blood’s A-B-O identity.
   2. A type – red blood cells have A antigens
   3. B type – red blood cells have B antigens
   4. AB type – red blood cells have both A and B antigens
   5. O type – red blood cells have neither A nor B antigens
   6. Rh factor – also known as D antigen
      a. Those people having D antigen are Rh positive.
      b. Those people lacking D antigen are Rh negative.

G. Immunoassay Techniques
   1. Immunoassay - the identification of a substance (as a protein) based on its capacity to act as an antigen
   2. EMIT – Enzyme Multiplied Immunoassay Technique – a technique used to detect drugs in urine
      a. This test is fast
      b. This test is highly sensitive
      c. This test is used extensively on alleged marijuana smokers.
   3. RIA – Radioimmunoassay – A sensitive method for detecting and measuring trace amounts of a biomolecule based on its ability to relocate a radioactive version of itself from combination with its explicit antibody.
      a. Substances have a similar chemical make up may give a false positive
      b. Positive results from this test must be confirmed using another reliable testing method.

III. Bloodstains - discolorations caused by blood

A. Color Tests
   1. Benzidine Color Test – Benzidine has been found to be a carcinogen and is no longer being used for that reason
   2. Kastle-Meyer Color Test – this test is based on the fact that blood hemoglobin possesses peroxidase-like activity, whereby if a bloodstain,
hydrogen peroxide, and phenolphthalein reagent are all mixed together, a pink color will result. (The presence of horseradish or potatoes will also result in a pink color.)

3. Luminol – when luminol reagent is sprayed on bloodstains, the bloodstains become luminescent. One must be in a darkened room to view this luminescence.

B. Precipitin Test – determines whether the bloodstain is human or animal
   1. Generally rabbits are injected with human blood and they then create antibodies. An investigator can then bleed the rabbit and use the serum that will react with human antigens.
   2. Human antiserum - a serum containing human antibodies
   3. Techniques for performing precipitin tests on bloodstains:
      a. Layer an extract of bloodstain on top of the human antiserum in a capillary tube and any protein of human origin will react with the antibodies present. You will see a ring or band where the two different liquids interface.
      b. Electrophoretic method – an electrical potential is applied to the gel medium resulting in a line of precipitation between the hole with the blood extract and the hold with the human antiserum
   4. Bloodstains 10-15 years old may still be usable using the precipitin reaction test. 4000-year-old mummies have also given positive reactions to this test.

C. Typing of Dried Stains
   1. Absorption-elution technique
      a. Step 1 – Treatment of antiserum antibody binds it to specific antigen
      b. Step 2 – Excess antibodies are removed by washing
      c. Step 3 – Antibodies and antigens are freed from one another by heating the stained material
      d. Step 4 – Agglutination occurs if antigens present on the added blood cells were originally on the stained material as well
   2. Secretors – 80% of people have high concentrations of blood-type antigens in other body fluids besides blood, such as saliva, semen, vaginal secretions, and gastric juice
   3. A-B-O typing can also be done on muscle or skin.

D. Blood Enzymes and Proteins
   1. Enzymes – these substances found in blood are becoming more and more important in determining the identities of victims and perpetrators
   2. Polymorphic – enzymes that can be separated into iso-enzymes
   3. Blood enzymes and proteins can be used to discriminate bloodstains.
IV. How to Safely and Effectively Preserve of Blood Evidence

A. Before any collection of blood evidence begins, bloodstains should be photographed and the entire scene should be documented through sketches, notes, photographs, and diagrams.

B. Gloves should be worn throughout the evidence gathering to prevent contamination of the evidence and to protect the crime scene investigator from contamination.

C. Collect a substrate with which to compare the blood evidence collected at the scene.
   1. Substrate - a substance acted upon (as by an enzyme)

D. Each stained article should be packaged separately in a paper bag or some other appropriate container

E. Evidence items such as cigarette butts and stamps should be picked up with clean forceps that have been cleaned with alcohol or distilled water between each use.

V. Wet blood vs. Dry blood

A. Wet blood is much more valuable to the forensic serologist because more tests can be run on wet blood than dried blood.
   1. Alcohol and drug use can only be determined through wet blood analysis

B. Blood begins to dry after 3-5 minutes of contact with air.

VI. Properties of Semen

A. Semen - a semi fluid mixture of cells, amino acids, sugars, salts, ions, and other organic and inorganic materials in a gel-like mass
   1. The collection of seminal stains is a two-step process. First you must locate the stain. Then you must conduct tests on the stain.
      a. Locate the stain, if necessary using the acid phosphatase color test (Human semen contains high levels of seminal acid phosphatase when compared with other body fluids)
      b. The presence of semen is indicated by the color purple within 30 seconds of the test.
      c. False positives – vegetable and fruit juices (cauliflower and watermelon), fungi, contraceptive cream, and vaginal secretions do react positively to the test, but none as quickly as semen
      d. The PSA, p30 test is the generally accepted method used to determine the presence of semen the world over.
e. For most of the male population, seminal fluid can yield a suspect's blood type. This information can be useful in exonerating innocent parties and convicting guilty parties.

VII. Rape Evidence Collection

A. Physical evidence is best gathered within hours, but can often be obtained for 5 days. The rape victim's body is the crime scene.

B. A law enforcement agency must request a medical professional to gather the physical evidence, collect biological samples, and physically examine the victim.
   1. This examination includes:
      a. a vaginal exam
         i. swabs from orifices and skin
         ii. swabs from condoms and floors or walls
      b. drawing blood
      c. use of a hospital room for gynecological examination
      d. the doctor's fee
      e. laboratory fee to determine if any "live" sperm are present
      f. samples of the victim's hair
      g. photos of any scrapes or bruises
   2. Other evidence gathered:
      a. the victim's clothing
         1. underwear - if drainage of seminal fluid to the underwear is present, the area should be tested for semen
      b. pictures of the area where the rape occurred
      c. any statements made by the victim to people after the assault occurred

C. Before the physical examination takes place, the medical professional/forensic nurse who will be performing the examination should first place a sheet on the floor.
   1. He/She should then lay a clean sheet of paper on top of the sheet.
   2. The victim should then remove her shoes and then step onto the sheet of paper.
   3. She should then disrobe while the medical professional/forensic nurse places each and every garment in a separate paper bag.
   4. After completely disrobing, the sheet of paper should be carefully folded to preserve any fibers, hairs, or other evidence that may be present on the victim's person or clothing.

D. Vaginal secretions - identification of vaginal secretions becomes extremely important when a foreign object has penetrated a victim during a sexual assault.
   1. PAS - periodic acid-Schiff - a reagent that stains glycogen in cellular cytoplasm a magenta color
2. If the amount of cells is limited, this test is not done in order to save the cells for the more reliable DNA testing.

E. According to the National Organization for Women, "DNA analysis has not been performed on as many as a half million "rape kits" because enforcement agencies say they can't pay the cost of the tests. Unless we ensure adequate funding, time limits on prosecution will expire before the perpetrators can even be identified."

F. The cost per rape kit is approximately $500.

G. According to the Center for Disease Control and Prevention, rape is the fastest growing violent crime in the United States.

VIII. Saliva

A. Saliva - a slightly alkaline secretion of water, mucin, protein, salts, and often a starch-splitting enzyme (as ptyalin) that is secreted into the mouth by salivary glands, lubricates ingested food, and often begins the breakdown of starches.

B. Tests for Saliva
   1. Amylase - Alpha-Amylase (an enzyme) is found in many body fluids and tissues
      a. Alpha-Amylase is a good marker because it is found in levels 50 times higher in saliva than in nearly all other body fluids
      b. No test is specific for saliva itself
   2. Starch - Iodine Test -
      a. 1881 - One of the earliest methods of saliva detection
      b. Produces false positive results
   3. Radial diffusion test - a version of the starch-iodine test still in use today
      a. Iodine is poured onto agar gel to which a known concentration of starch has been added. A small amount of the "saliva" in question is added to the wells in the gel. As the starch present diffuses, a circular void becomes apparent. This void is proportional to the amount of amylase present.

IX. Case factors which determine what to look for

A. Case type
   1. One victim - one suspect, multiple victims - one suspect, multiple victims - multiple suspects
   2. Victim (s) status - dead, alive, unconscious
   3. Suspect claims sexual intercourse was consensual
   4. Age and mental capacity of victim
5. Drug or alcohol use by either victim, suspect, or both
6. Previous relationships between the victim and suspect
7. Time elapsed since incident
8. Did the victim bathe or wash any body parts since the assault
9. Were the clothing or bedding washed since the assault

X. Alternate light sources used to locate body fluid evidence

A. Long-wave (320 - 400 nanometers) ultraviolet light is very useful for detecting semen, saliva, and blood
   1. Short-wave (180-280 nanometers) ultraviolet light is extremely harmful to humans
      a. Causes burns to unprotected skin
      b. Impairs vision in the absence of protective eyewear
      c. May damage DNA

B. Laser lights
   1. Spectra-Physics Model 171-19 Argon Ion Laser
   2. Plasma Kinetics Model 151 D Copper Vapor Laser

C. High intensity lights
   1. Payton Scientific Luma-Lite