



Introduction to Forensic Science – (Criminalistics)

Basic



Crime Scene Investigation Techniques

ITT Technical Institute  School of Criminal Justice 

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Basic

Crime Scene Investigation Techniques

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This week the student will learn:



- The nature of blood and its component parts
- Blood typing
- Tests used to discover drugs in urine
- Blood stain pattern analysis
- DNA, where it is found, how it is used to solve crimes
- HOMEWORK
 - Read chapters 2 & 3

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Review – Serology & DNA

- 1901 Karl Landsteiner
 - Announced the discovery of blood typing.
 - This was good
 - For years transfusions had ended in death
 - Now they new why
 - Blood of differing types has a tendency to coagulate
- He offered the classifications of A-B-O
- 1937 the Rh factors were discovered
- Now, more than 100 factors are known
- A-B-O are still the most important.

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Review – Serology & DNA

- Until the 1990s, this was the extent of forensic involvement because it was believed that only identical twins could have the exact same factors.
- Now we use DeoxyriboNucleic Acid (DNA)
- Blood is comprised of cells, enzymes, proteins, and inorganic substances.
- Plasma (fluid portion of blood) accounts for 55%.
 - Red blood cells (erythrocytes)
 - White blood cells (leukocytes)
 - Platelets

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Review – Serology & DNA

- Blood clots when a protein in the plasma called fibrin traps and enmeshes a red blood cell.
- Remove the clot and serum remains.
- The red blood cells take oxygen to the cells and remove carbon dioxide
- On the surface of each cell are millions of chemical structures called antigens.
- These impart the blood type characteristics.
 - A blood has A type antigens
 - B blood has B type antigens
 - AB blood has both

Review – Serology & DNA

- Type O blood has neither.
- The Rh factor is sometimes called the D antigen.
 - + blood types have this antigen
 - - blood types do not
- Serum contains antibodies
- For every antigen there exists a specific antibody.
- An antibody will only react with its specific antigen
 - Serum containing anti-B added to B blood will immediately combine.
 - Antibodies are bivalent or have two reactive sites.

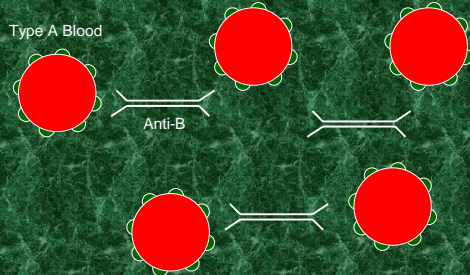
Review – Serology & DNA

- This means that each antibody can attach to two red blood cells creating clumping or agglutination.
- A blood
 - Has A antigens on the cells
 - The serum contains anti-B antibodies
 - They live in harmony
- Introduce a B blood to this person
- The Anti-B antibodies attack and surround the B Blood causing clotting.
- The clot cannot be pumped and stops blood flow.
- The person dies
- This is a bad thing.

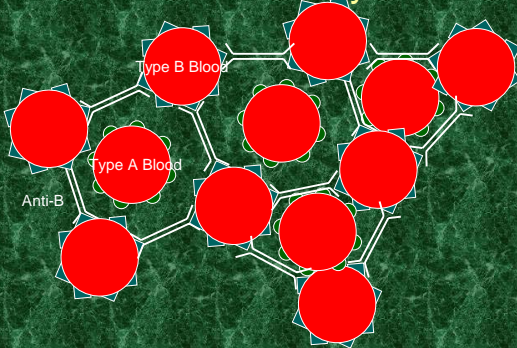
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Blood Type	Antigens on red blood cells	Antibodies in Serum
A	A	Anti-B
B	B	Anti-A
AB	A & B	None
O	None	Anti-A & Anti-B

Review – Serology & DNA



Review – Serology & DNA



Review – Serology & DNA

- In the U.S.
 - O = 43%
 - A = 42%
 - B = 12%
 - AB = 3%
- Serology actually means the study of antigen-antibody reactions.
- To test blood, use Anti-A and Anti-B serum
 - Type A will clot with Anti-A
 - Type B will clot with Anti-B
 - Type AB will clot with both
 - Type O will not clot with either.



Review – Serology & DNA

- Antibodies for drugs can be created, so that presumptive tests can be done quickly.
 - Inject the drug with a protein into an animal
 - The animal produces antibodies
 - The animal's blood serum now contains antibodies for that drug
- One commercial test available is the EMIT (enzyme-multiplied immunoassay technique).
 - Used to test for methadone, marijuana and others in the urine.
 - Drugs are broken down into other substances in the body

Review – Serology & DNA

- For example, one by-product of marijuana is THC-9-carboxylic acid.
 - Usually found in quantities of less than 1,000,000th of a gram
 - This level is easily detected by this method
 - May last 2 – 10 days
- Another test is the RIA (radioimmunoassay)
 - Rather than enzymes, it uses radioactive tags
- These techniques are NOT specific for any drug
 - Similar chemical compositions will react

Review – Serology & DNA

- When an animal is injected with the drug/protein mixture, the animal creates a host of different antibodies that attack various sites on the intruder antigen
- These are called polyclonal antibodies
- Not all polyclonals will be the same, therefore the tests will be more or less accurate depending upon the batch.
- Monoclonals will attack one and only one site on the antigen, never vary

Review – Serology & DNA

- The three primary questions when examining a blood scene are:
 - Is it even blood?
 - From what species is it?
 - If human, how specific can identification be?
- When determining if the stain is blood, the Kastle-Meyer color test is used.
 - Phenolphthalein
 - Tests for hemoglobin
- Hemoglobin is the protein that transports oxygen and gives blood a red color

Review – Serology & DNA

- When a blood stain, phenolphthalein reagent, and hydrogen peroxide are mixed, a deep pink color emerges.
 - Potatoes and horseradish produce the same effect on this test.
- In the field, Hemastix can also be used.
 - Designed as a urine dipstick test for blood
 - In the field, wet with distilled water and place on stain
 - A green color is indicative of blood
- Luminol is another test procedure

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- Luminol can be sprayed over a very large area
- Must be in a darkened area
- When illuminated by an ALS the stain will fluoresce.
- Capable of detecting blood diluted 300,000 times
- Luminol will not interfere with later DNA testing
- Microcrystalline tests available are the Takayama and Teichmann tests
- Both are susceptible to interference from contaminants

Review – Serology & DNA

- The precipitin test is done next, to determine if it is human blood
- Precipitin tests are available for several species, dog, cat, deer, human, etc.
- The test is made by injecting human blood into a rabbit
- The rabbit creates antibodies
- These are removed from the serum of the rabbit blood
- Known as human antiserum

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- When human blood and rabbit serum are combined, a cloudy band will form between the two bloods
- Tests include:
 - Capillary tube
 - Gel diffusion
 - Electrophoretic method
- 10 – 15 year old blood stains may have a positive precipitin test.
 - 5,000 year old mummies have provided positive tests
- Since DNA has replaced enzyme study, we will not spend time there

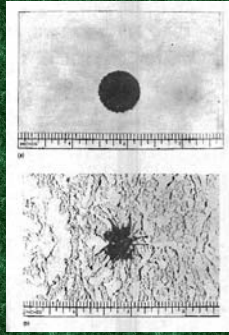


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- When examining blood stains, their location, shape and distribution may be useful in reconstructing their formation.
- Similar surfaces must be used for comparison
- Herbert L. MacDonell has authored THE textbook on the subject
- Lets examine how his study has helped the field of forensics

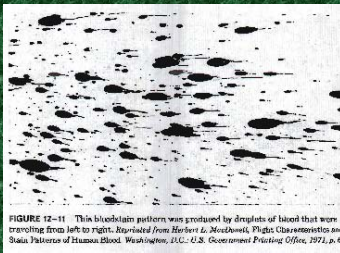
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- Surface texture is of prime importance when interpreting patterns
- The pointed end of a bloodstain ALWAYS faces its direction of travel



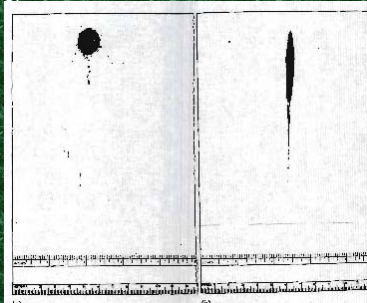
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- The pointed end of a bloodstain ALWAYS faces its direction of travel



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- The impact angle of blood on a flat surface can be determined by the degree of circular distortion



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- The origin of blood spatter in a two-dimensional configuration can be determined by extrapolating lines through the droplets

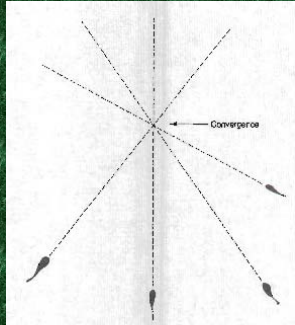


FIGURE 12-13 Illustration of stain convergence on a two-dimensional plane which the stains are. Bunker & Assoc., Inc. School of Criminal Justice

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- The gene is the basic unit of heredity
- They are positioned on chromosomes
- All human cells contain 46 chromosomes, in 23 pairs, except three
- Red blood cell, zero
- (The egg and sperm each only have 23 unmated chromosomes)
- The man determines the gender of the fetus
 - The egg cell contains an X chromosome
 - The sperm contains an X or Y chromosome

Review – Serology & DNA

- An XX pairing makes a female, an XY makes a male.
- Genes are aligned in matching locations on chromosomes
 - For example eye color genes will always be in the same location on two chromosome chains
- Two matching genes are said to be homozygous, two differing ones are heterozygous
 - Blood types are one example
 - A & A is homozygous
 - A & O is heterozygous
 - A & B are dominant

Review – Serology & DNA

- If the child gets A and O, it will have A
- If the child gets B and O, it will have B
- If the child gets A and B, it will have AB
- If the child gets O and O, it will have O
- These types of different pairings are known as “alleles”.
- A person may have a phenotype of A blood
- No test can determine the genotype (whether it was caused by an AA pairing or an AO pairing).

Review – Serology & DNA

- In paternity testing, often this is the first level of testing
- The next is the HLA (human leukocyte antigen).
 - A complex system of antigens on the white blood cells
 - Better than 90% probability of father
- DNA tests raise this to over 99%
- The NORMAL male releases 2.5 to 6.0 milliliters of seminal fluid during ejaculation
- Each milliliter contains more than 100 million sperm.



Review – Serology & DNA

- Looking for visual evidence of a semen stain is usually fruitless.
- Use of the acid phosphatase test is better.
- This is an enzyme that is secreted by the prostate into the semen
- The concentration is 400 times that found in any other bodily fluid
- Don't worry about the chemical make-up of the 2 tests.
- They can provide false results and must be verified by other means

Review – Serology & DNA

- Items that will produce false tests:
 - Cauliflower
 - Watermelon
 - Fungi
 - Contraceptive creams
 - Vaginal secretions
- Semen usually reacts quicker to the test, < 30 seconds
- Presence of sperm is considered positive proof of semen.
- Sperm can be separated by immersion of stained material in water and rapid stirring
- A drop of the water is then dried on a slide

Review – Serology & DNA

- The slide is then stained and viewed at approximately 400x
- Dried spermatozoa are very brittle and disintegrate easily, they also cling to fabrics
- Routine collection can destroy remnants
- Often sex suspects suffer from oligospermia (low sperm count) or aspermia (no sperm).
- Vasectomies are one cause of aspermia.
- If no sperm, how can the presence of semen be confirmed?

Review – Serology & DNA

- Use of the p30 test (prostate specific antigen, or PSA).
- To collect and package evidence:
 - Place a clean sheet on floor and place clean paper sheet over it, have the person disrobe on the paper
 - Remove shoes first
 - Collect all clothing (as removed) and place in separate paper bags
 - Fold paper on floor to contain any trace that has fallen into it, and package it
 - Try never to fold through a suspected stain, and never place that area against the paper bag.

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- Package the protective gloves you wear and submit those as well
- Evidence collected during physical exam:
 - Page 353
 - Pubic combings
 - Pubic hair standards 15-20 full-length (cut)
 - Vaginal swabs and smear
 - Rectal swabs and smear
 - Oral swabs and smear
 - Head hair standards 50 full-length (cut)
 - Blood sample 7 ml
 - Fingernail scrapings
 - Urine specimen 30 ml
 - Swabs for DNA at any location the suspect touched with his mouth



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- Motile or living sperm can live in the vaginal canal for up to 6 hours (of a live person)
- Microscopic exam of a vaginal smear must be performed immediately upon harvest of sample
- Intact sperm (heads and tails) have been located after 72 hours, but usually will not last even 16.
- Also, make sure to obtain a buccal swab from any consenting sexual partner within the last 72 hours





Review – Serology & DNA

- DNA
- DeoxyriboNucleic Acid
- There are more than 60 trillion cells in a human body (more in Mr. Marshall)
- Each contain strands of chromosomes
- Each strand of chromosome contains nearly 30,000 genes
- Each gene carries out a single body function
- DNA first discovered in 1868
- Not understood until 1950s

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- DNA is a polymer (a very large molecule made up of a series of repeating units)
- In DNA the polymer is comprised of nucleotides
- A nucleotide is comprised of three units
 - A sugar molecule
 - A phosphorous containing group
 - A nitrogen containing molecule – base
- The sugar and the phosphates form a strand called the backbone
- Bases attach to the sugar molecule

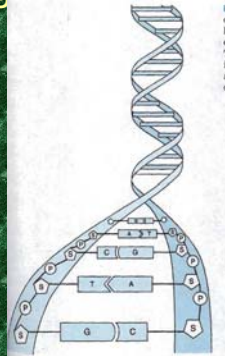
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- There are only four bases in DNA
 - Adenine
 - Cytocine
 - Guanine (not guano)
 - Thymine
 - Usually shown as A, C, G, and T
 - G always pairs with C
 - A always pairs with T
- This pattern is known as complimentary base pairing.
- In theory, there is no limit to the length of a DNA strand.
- Two backbones are intertwined in a form known as a double helix.

Review – Serology & DNA

- A representative section of a double helix DNA strand
- Any base can follow another on a DNA strand
- Avg. strand contains 100 million base pairs
- The order defines role and function.



Review – Serology & DNA

- The DNA order directs the building of proteins
- Proteins are made up of amino acids
- There are 20 known amino acids
- There sequence makes ... us.

	Normal hemoglobin	Sickle-cell hemoglobin
1	valine	valine
2	histidine	histidine
3	leucine	leucine
4	threonine	threonine
5	proline	proline
6	glutamate	valine
7	glutamate	glutamate

(a) (b)

Review – Serology & DNA

- Each amino acid is directed by the combination of three bases.
- C-G-T = Alanine
- C-T-A = Aspartate
- A-A-A = Phenylalanine
- Therefore, C-G-T-C-T-A-A-A-A-C-G-T
 - Alanine
 - Aspartate
 - Phenylalanine
 - Alanine
- Normal blood = ...C-C-T-G-{A}-G-G-A-G
- Sickle-cell = ...C-C-T-G-{T}-G-G-A-G

Review – Serology & DNA

- This code is not restricted to humans.
- Almost all living cells use this same genetic code.
- The human genome is comprised of approx 3 billion base pairs
- To replicate DNA requires the unwinding of the double helix.
- Each half is flooded with free nucleotides, and will replicate the missing half
- Two chains now exist where there was one

Review – Serology & DNA

- PCR – polymerase chain reaction is one method of duplicating a DNA strand outside the cell
- Small quantities or broken segments can be copied with this method
- More than 30% of the human genome is comprised of repeating strands of DNA
- All humans have the same type of repeats, but variation is tremendous
 - The purpose is not known, yet

Review – Serology & DNA

- RFLPs – restriction fragment length polymorphisms
- The repeats are cut from the strand by a restriction enzyme
- The length of the repeating fragments permit scientists to distinguish two people
- Only a limited number of people would have the same length repeating fragment.
- Duplication on additional repeats will eliminate other possible donors
- Seven “probes” are solid evidence of ID

Review – Serology & DNA

- When choosing probes, fragments with little commonality are chosen. If four probes, each representing 1 in 100 of the population are used, the result is 1 in 100,000,000 for a match.
- This method is outdated, but was used in a famous trial.
- Monica's dress had a 7 probe match, (1 in 8 trillion) to President William Clinton.
- That made it difficult for him to deny, ... any longer.

Review – Serology & DNA

- PCR is the method of choice since the mid 1990s
- PCR is best used on strands of only a couple hundred bases
- Can work with as few as 9 cells
- Will produce millions in a few hours
- This process has been used on soda cans, cigarette butts, envelopes, stamps, etc.
- STRs – short tandem repeats are the new thing.
 - They look for repeats like RFLPs
 - Only need 3-7 bases

Review – Serology & DNA

- The entire strand is only 400 bases long
- Much less susceptible to damage or decomposition
- Ideal size for replication
- Less than 1 billionth of a gram needed for testing
- 50 – 100X less RFLP
- The TH01 variant of A-T-C has between 5 and 11 repeats. Every human has two sets, one from each parent.
- A stain with a 6 and an 8 repeat is represented in 3.5% of the population
- The DNA database (CODIS) requires 13 STRs

Review – Serology & DNA

- Mitochondrial DNA is found outside the nucleus of the cell and is inherited from the mother.
- Mitochondria supply the energy for our bodies.
- Each mitochondria contains several loops of DNA
- Each cell has 100s or 1000s of mitochondria
- This makes them extremely easy to get DNA from and very plentiful
- Nuclear DNA has one copy per cell by comparison
- mtDNA is very costly, difficult and time consuming

Review – Serology & DNA

- Prior to harvesting, the area must be photographed, sketched and notes recorded.
- Each item should be packaged separately in a paper bag or ventilated cardboard box.
- Swabs cannot be packaged in a wet state (like Florida).
- Buccal cells are from the inner lining of the cheek and remove readily.
- Always use a clean set of gloves for each item collected.



