FORENSIC SEROLOGY
Dr. Sam Sheppard was accused of beating his wife to death.
- The show “The Fugitive” was based on his life.

He said he was asleep in the living room when his wife was attacked and the intruder knocked him unconscious.
- It looked bad for him since he was having an affair.

The coroner found the shape of a surgical instrument in the blood.

He was convicted and sent to jail for 10 years before the supreme court overturned the verdict because of juror prejudice.

At the second trial, the coroner backed off his previous findings.

The Doctor had blood spatter on his watch.
- The prosecution said it was from when he beat her.
- The defense said it was from when he was taking her pulse. The defense also showed from the blood spatter that the killer was left handed and the doctor was right handed. The jury took less than 12 hours to find him innocent based on the blood evidence.
RED BLOOD CELLS
Blood typing was first introduced in 1901.
- This was important because if you mix two types of blood they will clot inside the arteries and veins.
Because of this we came up with the A-B-O system.
- This was very important for blood transfusions.
By 1937 the Rh factor in blood was discovered.
More than 100 different blood factors have now been discovered.
Until 1990’s, blood factors were the best way of identifying a suspect.

- No two people have the same blood factors, not even identical twins.

There is generally blood at a crime scene.

Blood gets transferred from attacker to victim and can be used to identify the attacker.

DNA analysis has taken over as the main identifier in crimes.
**THE NATURE OF BLOOD**

- Blood is a mixture of lots of different things.
  - cells, enzymes, proteins, inorganic substances.
- Plasma = the fluid portion of the blood
  - made mainly of water and makes up 55% of the blood
- There are three main solid parts in blood.
  - erythrocytes – red blood cells – these carry oxygen to every cell in the body
  - leukocytes – white blood cells – these help fight disease in the body.
  - platelets – these help form blood clots in wounds
- Blood clots when a protein in plasma known as fibrin makes a web and traps red blood cells.
Red and white blood cells
If the clotted material were to be removed, you would be left with a yellowish called serum.

Blood chemistry is a HUGE field.

We are only going to discuss red blood cells and serum.
Antigen = a substance, usually a protein, that stimulates the body to produce antibodies against it.

Blood antigens are grouped depending on their relationship to one another.

There are more than 15 different groups.

A – B – O and Rh systems are the most important.

If someone is type A, their red blood cells have A antigens on them.

If they are type B, they have B antigens.

If they are O, they do not have either type of antigen.

The Rh factor is also called the D antigen.
Rh positive means they have the antigen, and Rh negative means they do not.

When doing a blood transfusion, you need to know A-B-O and Rh factor.

Serum is important because it contains antibodies.

Antibody = a protein that destroys or turns off a specific antigen.

For every antigen in your body, there is a specific antibody.

Each antibody symbol has the prefix “anti” followed by the name of the specific antibody.

So, Anti – A is specific only for the A antigen, etc.

If anti – A is mixed with the A antibody the two combine.

This causes agglutination, or clumping together of the red blood cells.
Nature takes care of this.

There are four blood types: A, B, O, AB

If you have type A blood, you will have anti-B so it does not clump.

<table>
<thead>
<tr>
<th>Blood Type</th>
<th>Antigen on RBC's</th>
<th>Antibodies</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>A</td>
<td>Anti-B</td>
</tr>
<tr>
<td>B</td>
<td>B</td>
<td>Anti-A</td>
</tr>
<tr>
<td>AB</td>
<td>AB</td>
<td>Neither anti-a or anti-B</td>
</tr>
<tr>
<td>O</td>
<td>Neither A or B</td>
<td>Both anti-A and anti-B</td>
</tr>
</tbody>
</table>
• Looking at the chart, we can see why blood clots when you mix blood types.
• People with AB blood can get blood from anyone because they do not have any antibodies.
• People with O blood can give blood to anybody because they do not have any antigens.
Serology = the study of antigen-antibody reactions.

Blood typing (A,B,O) is the most common lab test run.

You need just 2 antiserums to test for blood type.

Type A clots with anti-A serum, Type B clots with anti-B serum

Type AB clots when anti-A and anti-B are both present

Type O will not clot with either or both serums.

In the U.S.A., 43% of people have O, 42% have A, 12% have B and 3% have AB.
DRUG TESTING
EMIT testing
- Stands for enzyme-multiplied immunoassay technique.
- We are now using antigen-antibody reactions to detect drugs in blood and urine.
- Antibodies that react with drugs do not exist in nature.
- We have to create these antigens in a lab.
- We inject animals (like rabbits) with a drug that has been combined with a protein.
- We take serum from the animal because it has antibodies in it that are specific to the drug.
A typical test begins by adding antibodies for a drug to someone’s urine. Then a chemically labeled version of the drug will be added to the urine. If they do not have drugs in their system, the test will show all of the labeled drugs and antibodies combined with none left over. If they do have drugs in their system, the labeled and unlabeled drugs will fight for the antibodies. This will leave labeled drugs in the urine that we can measure. We can tell how much of the drug is in their system by how much we measure.
IMMUNOASSAY TESTS

• Thousands of people do voluntary drug tests every day in the U.S.
• Military, police, transportation, sports, pre-employment tests.
• Immunoassay testing lets us do large amounts of tests in a very short period of time.
• The serums are made commercially by large pharmaceutical companies.
• Each serum will react with only one type of drug.
• You can do 100’s of tests from one urine sample.
• Problems with immunoassay tests
  - They are screening tests and the result must be confirmed by other tests.
  - Some drugs will stay in the body for over a week, and there is no way of telling when you took the drug.
There are three questions a forensic scientist must ask when looking at blood.

1) Is it blood?
2) From what species did it come from?
3) If it is human blood, how close can we associate it to a specific person?

A) Color tests
- We use phenolphthalein for color tests.
- When phenolphthalein is mixed with the blood’s hemoglobin, it produces a deep pink color.
- It will also turn pink if put on potatoes and horseradish.
- Hemastix strips are moistened with distilled water and put on blood stains.
- If it turns green, it is blood.

B) Luminol
- When sprayed on blood, it will fluoresce (glow) blue when the lights are turned off.
- It will detect blood that has been diluted up to 300,000 times.
- It does not mess up DNA tests.

C) Precipitin test
- This tells if the blood is human or animal.
- If you put human antiserum and a human blood sample together, they will make a ring where the two samples meet.
If it does not make a ring, it is animal blood.
- It is very sensitive – mummies blood give a positive test.

D) Gel diffusion
- Antigens and antibodies will move towards each other when put on a gel plate.
- Each is put in a hole opposite the other.
- If the blood is human, they will form a line between the two holes.
- Once the blood has been determined to be human, DNA testing takes over.
The location, distribution and appearance of blood stains and spatters is useful in finding out what caused the bleeding.

It takes an expert examiner to make sense of it.

To interpret bloodstains in a lab requires carefully controlled labs using materials identical to the crime scene.

What you need to figure out before doing an experiment

1) Surface texture
   - hard, non-porous materials (glass) have less spatter than soft, porous material (carpet)

2) The direction the blood is traveling can be shown by the stains shape.
   - The pointed end always faces its direction of travel.
3) The angle the blood hit can be determined.
   - At 90° it is circular
   - The lower the angle, the more spread out the drop is.
4) To find where the blood came from
   - Draw a line from each blood drop and where they cross is where it came from.
• Heredity = the inheriting of traits from the parents.
• Gene = the basic unit of heredity consisting of a DNA segment on a chromosome.
  - Each gene by itself, or with other genes, controls a certain characteristic of an organism.
• Chromosome = a threadlike structure in the cell’s nucleus; where the genes are located.
  - Humans have 46 (23 pairs) of chromosomes in each cell.
  - With the exception of the sperm or egg – they only have 23 chromosomes.
  - When the sperm and egg come in contact with each other (fertilization), they make a zygote that has 46 chromosomes.
This is why you have characteristics from both parents.

Each egg has 2 X chromosomes

All female cells have 2 X chromosomes

Each sperm has an X and a Y chromosome

The male will determine whether the child is male or female.

We use Punnett squares to figure out all of the possible combinations.

We can use this to find the genotypes and phenotypes

Phenotype = what it physically looks like

Genotype = what alleles are being combined

Do a punnett square to prove this.
• Genes come in pairs, one from mom and one from dad.
• Locus = where on the chromosome the gene is located.
• Ex) eye color – the gene from mom is lined up with the gene from dad.
• These paired genes are called alleles
• Blood type alleles
  - Made of 3 genes (A, B, O)
  - Each gene has 2 alleles, so you have a total of 6 alleles that can be joined
  - AA = homozygous = 2 identical alleles
  - AO = heterozygous = 2 different alleles
Of the 2 alleles, one will be dominant

Dominant = the characteristic that you see

The other allele will be Recessive = the allele that is covered up.

A & B are dominant over O
Do a Punnett square for the following:
- Homozygous O with heterozygous AO
- Heterozygous AB with homozygous B
- When we test for blood, we can only see the phenotype
- Without very specialized equipment we cannot tell the genotype.
- We do use genotyping in paternity testing
- You use the genotypes from the parents and compare them to the kids’
- This is not a definitive test
- It can only exclude or include individuals
- We have to use DNA testing to confirm paternity.
Many sex crimes are committed each day

Forensic scientists have to sift through ALL of the stains in underwear, sheets, carpets, etc.

The first part of testing begins with finding the stain.

The second part is actually testing it.

Finding the semen

1) Acid Phosphate test
   - There is 400X’s more acid phosphate in semen than in any other body fluid.
   - There are several chemicals that will detect acid phosphate.
- Alpha naphthylphosphate and Fast Blue B dye turn purple when they come in contact with semen.
- We use this on fabrics and surfaces.
- If you are doing a big area (carpet, sheets), you use 4-methyl umbelliferyl phosphate (MUD).
- It will glow when it comes in contact with semen.
- A reaction time of less than 30 seconds means you have found semen, not something else.
• Microscopic examination of semen
• They are very easy to identify under a microscope
• Spermatozoa have a head and a long, thin tail
• Put the sample in a small amount of distilled water and stir
• Some of the spermatozoa will go into the water
• A drop of this water will be dried, stained and looked at under 400X power.
• Normal males release 250-600 million spermatozoa each time.
• There are problems collecting the sperm for testing
• They bind very tightly to fabrics, so it is hard to get a sample.
• They are very brittle when they dry.
• The male may have a low sperm count or no sperm count (vasectomy)
COLLECTION OF RAPE EVIDENCE

• If there is no semen, there is still other evidence.
• Bruises and bleeding = a violent crime
• Blood, hair, fibers can be transferred.
• All clothing is put into a paper, not plastic, bag (no static)

Steps in collecting evidence
1) Put a clean sheet on the floor and lay clean white paper over it
2) Remove the shoes, stand on paper and disrobe
3) Collect each piece of clothing as it is removed and put into paper bag
4) Fold paper to collect any loose pieces and place in paper bag
5) Collect anything else associated with the rape
• You may have cut out pieces that have the stains on them to get them to the lab
• In the lab, they will try to match DNA from semen, sweat or skin cells.

Rape victims must have a physical examination as soon as possible.

The following items are collected during the exam.

1) Pubic combings – comb the victims pubic hair and catch any loose hairs on a towel

2) Pubic hair reference samples – cut 15-20 full length pubic hairs at the skin line.
3) External genital dry skin areas – use at least one wet and one dry swab
4) Vaginal swabs and smears – use 2 swabs at the same time and let dry before packaging.
   - Use two more swabs at the same time and smear them on slides. Let these air dry before packaging.
5) Cervix swabs – 2 swabs at same time, air dry, package
6) Rectal swabs and smears – only if needed, do same as vaginal swabs and smears.
7) Oral swabs and smears – only if needed – 2 swabs at same time – swab cheek and gum – use both swabs to smear one slide – air dry and package.
8) Head hairs – cut at skin line – at least 5 from center, front, back, left and right sides.

9) Blood sample – 7 milliliters – for DNA and toxicology

10) Fingernail scrapings – scrape with a dull object onto clean paper – one paper for each hand – fold paper and package

11) All clothing in paper bag.

12) Urine sample – 30 milliliters – for chemical (GHB, Rohypnol)
If the victim was bitten, licked, etc., they will collect saliva.

1) Moisten swab using distilled water
2) Rotate swab over area
3) Rotate dry swab over same area
4) Air dry and package both swabs together.

If the suspect is apprehended

1) All clothing or anything worn during the assault will be collected and put in paper bag.
2) Pubic hair combings
3) Pulled (not cut) head and pubic hairs for DNA
4) Penile swab if less that 24 hours after assault
5) Blood sample for comparison and DNA

It is important that all tests happen as quickly as possible.

- Sperm only lives 4-6 hours in the vagina
- Dead sperm can be found up to 3 days
- Acid phosphate disappears after 48 hours
• If the victim had consensual sex with anyone prior to the rape
• Need to get samples from any partners from the past 72 hours