Serology
Ch. 12
What makes up our blood?

- **RED BLOOD CELLS** (Erythrocytes) – The most abundant cells in our blood; they are produced in the bone marrow and contain a protein called hemoglobin that carries oxygen to our cells.

- **WHITE BLOOD CELLS** (Leukocytes) – They are part of the immune system and destroy infectious agents called pathogens.

- **PLASMA** – This is the yellowish liquid portion of blood that contains electrolytes, nutrients and vitamins, hormones, clotting factors, and proteins such as antibodies to fight infection.

- **PLATELETS** (Thrombocytes) – The clotting factors that are carried in the plasma; they clot together in a process called coagulation to seal a wound and prevent a loss of blood.
Blood Facts

The average adult has about **FIVE** liters of blood inside of their body, which makes up 7-8% of their body weight.

Blood is living **tissue** that carries oxygen and nutrients to all parts of the body, and carries carbon dioxide and other waste products back to the lungs, kidneys and liver for disposal. It also fights against **infection** and helps heal **wounds**, so we can stay healthy.

There are about one **billion** red blood cells in two to three drops of blood. For every **600** red blood cells, there are about **40** platelets and **one** white cell.
Blood Stain Characterization

● Three Questions:
  ● Is it blood?
  ● If it is blood, which species did it come from?
  ● If it is human blood, can we isolate a single individual?
Is it Blood?

- **Kastle-Meyer Test**
  - Reacts with blood to give a bright pink color
  - Detects peroxidase (found in plant and animal cells)

- **Hemastick**
  - Originally designed for urine

- **Luminol**
  - Causes blood to glow when exposed to UV light.
  - Can detect blood diluted up to 300,000 times.
  - Does not affect the DNA of a sample
  - Used since 1937
  - False results are possible
Is it human blood?

- Precipitin test
  - Antiserums have been designed for most species of animals. If the blood is human then it should react with human antiserum.
  - The test is very sensitive and requires only a minute amount of blood. Positive tests have resulted for samples 10-15 years old and tissue sample from mummies that are thousands of years old.
Whose blood is it?

- Before 1995, we could only identify a source down to a particular blood group (ABO + enzymes).
  - One particular enzyme studied was PGM which exists in different forms
- Since the onset of DNA testing, blood typing has become all but obsolete.
Karl Landsteiner

- In 1901 discovered blood types
- Earned him a Nobel Prize
- Prior to this discovery, transfusions typically resulted in coagulation, resulting in immediate death.
- Over 100 antigens have been located in the blood, the two most important are ABO and Rh
Your blood type is established before you are BORN, by specific GENES inherited from your parents.

These two genes - one gene from your MOTHER and one from your FATHER - determine your blood type by causing proteins called AGGLUTINOGENS (a type of antigen) to exist on the surface of all of your red blood cells.
Genetics of Blood Types

- In addition to agglutinogens (antigens), there are antibodies circulating in the plasma.
- **Antibodies** bind to **antigens** in a process known as **agglutination** which is a life-threatening event.
Antigen-Antibody Reaction

- For every antigen there exists a specific antibodies
- Antibodies are named for the antigen to which they bind. Meaning A antibodies bind to A surface antigens and no other.
- Antibodies typically have 2 binding sites. This binding and crosslinking is called agglutination.
Blood Types

- A person’s blood type has two components:
  - ABO group
  - Rhesus (Rh) factor
The Rh factor or Rhesus group was named for the Rhesus monkey (the location where it was first identified).

There are two possible phenotypes:

- Rh+ (a person displays Rh antigen on their RBCs)
- Rh- (a person displays no antigen on their RBC's)
Rhesus Group

- Since a person with Rh+ blood is used to the surface antigen, they have no problem when their cells come in contact with it.
- A person with Rh- blood, however, may develop antibodies to the Rh+ antigen because their body sees it as a foreign cell. This can cause the blood to agglutinate (clump). This poses a significant problem during pregnancy.
Transfusion Concerns

- Can a person with positive blood, receive a transplant from someone with negative blood?
  - Absolutely!! Because the negative blood has no surface antigen, the body doesn’t even realize it’s there.

- Can a person with negative blood, receive a transplant from someone with positive blood?
  - No!! The antigen-antibody reaction would be life threatening
The Rhesus factor follows the rules of simple Mendelian inheritance.

There are two alleles (+ and -) with + being the dominant allele.
Rhesus Inheritance

- So could two Rh- parent’s have a Rh+ child?
- What about an Rh- woman and an Rh+ man?
- What about 2 Rh+ people?
- Why are Rh+ women not given Rhogam?
ABO Groups

- There are four possible phenotypes
  - A
  - B
  - AB
  - O
- A person’s phenotype tells us the surface antigen (agglutinogen) that their RBCs display
# The ABO Blood System

<table>
<thead>
<tr>
<th>Blood Type (genotype)</th>
<th>Type A (AA, AO)</th>
<th>Type B (BB, BO)</th>
<th>Type AB (AB)</th>
<th>Type O (OO)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red Blood Cell Surface Proteins (phenotype)</td>
<td>A agglutinogens only</td>
<td>B agglutinogens only</td>
<td>A and B agglutinogens</td>
<td>No agglutinogens</td>
</tr>
<tr>
<td>Plasma Antibodies (phenotype)</td>
<td>b agglutinin only</td>
<td>a agglutinin only</td>
<td>No agglutinin</td>
<td>a and b agglutinin</td>
</tr>
</tbody>
</table>
Distribution

Percent of population that has the B allele:

- Yellow: 0-5%
- Light orange: 5-10%
- Pink: 10-15%
- Dark orange: 15-20%
- Red: 20-25%
- Dark red: 25-30%
Distribution

Percent of population that has the A allele

0-5
5-10
10-15
15-20
20-25
25-30
30-35
35-40+
Distribution

Percent of population that has the O blood type

- 50-60
- 60-70
- 70-80
- 80-90
- 90-100

haematology
<table>
<thead>
<tr>
<th>TYPE</th>
<th>DISTRIBUTION</th>
<th>RATIOS</th>
</tr>
</thead>
<tbody>
<tr>
<td>O +</td>
<td>1 person in 3</td>
<td>38.4%</td>
</tr>
<tr>
<td>O -</td>
<td>1 person in 15</td>
<td>7.7%</td>
</tr>
<tr>
<td>A +</td>
<td>1 person in 3</td>
<td>32.3%</td>
</tr>
<tr>
<td>A -</td>
<td>1 person in 16</td>
<td>6.5%</td>
</tr>
<tr>
<td>B +</td>
<td>1 person in 12</td>
<td>9.4%</td>
</tr>
<tr>
<td>B -</td>
<td>1 person in 67</td>
<td>1.7%</td>
</tr>
<tr>
<td>AB +</td>
<td>1 person in 29</td>
<td>3.2%</td>
</tr>
<tr>
<td>AB -</td>
<td>1 person in 167</td>
<td>0.7%</td>
</tr>
</tbody>
</table>

http://www.bloodbook.com/type-facts.html
ABO Inheritance

- There are 3 possible alleles (A, B, O).
- A and B are codominant over O.
ABO Inheritance

- Can a parent with A blood and a parent with B blood give birth to a child with O blood?
- Can a two parent’s with AB blood have a child with AB blood?
- If a mother has type A blood and her child is type B then what are the possible blood types for the father?
Transfusion Concerns

- Who is the universal donor?
- Who is the universal recipient?
Matching by Blood Type

Prior to 1990, forensic scientists often tried to prove a match between blood samples by showing that the antigens between the 2 samples matched. There theory was that no 2 people could possibly share the same exact antigens.

This was replaced by DNA fingerprinting,
What does the abbreviation BPA represent? Bloodstain Pattern Analysis

What can an investigator learn from the analysis of a blood spatter?

- Type and velocity of weapon
- Number of blows
- Handedness of assailant (right or left-handed)
- Position and movements of the victim and assailant during and after the attack
- Which wounds were inflicted first
- Type of injuries
- How long ago the crime was committed
- Whether death was immediate or delayed
If 1.5L of blood are lost, unconsciousness may occur.

Death becomes a risk at 40% blood loss.
Bloodstain Pattern Analysis Terms

- **Spatter** – Bloodstains created from the application of force to the area where the blood originated.
- **Origin/Source** – The place from where the blood spatter came from or originated.
- **Angle of Impact** – The angle at which a blood droplet strikes a surface.
  - **Parent Drop** – The droplet from which a satellite spatter originates.
  - **Satellite Spatters** – Small drops of blood that break off from the parent spatter when the blood droplet hits a surface.
  - **Spines** – The pointed edges of a stain that radiate out from the spatter; can help determine the direction from which the blood traveled.
How Bloodstain Pattern Analysis Works

The diameter of the bloodstains increases as the height increases:
- 7 ft
- 6 ft
- 5 ft
- 4 ft
- 3 ft
- 2 ft
- 1 ft
- 6 in
Surface texture is extremely important in spatter analysis. The harder and less porous the surface, the less spatter.
Direction of Travel

- The pointed end of the spatter indicates the direction of travel.
Angle of Impact

- Angle of impact can be determined by the degree of circular distortion.
Point of Origin

- Point of origin can be established by drawing straight lines through the long axis of blood stains and finding the point of convergence.
Types of Bloodstain Patterns

- **Passive Bloodstains**
  - Patterns created from the force of **gravity**
  - Drop, series of drops, **flow** patterns, blood **pools**, etc.

- **Projected Bloodstains**
  - Patterns that occur when a **force** is applied to the **source** of the blood
  - Includes low, medium, or high **impact** spatters, cast-off, arterial spurting, **expiratory** blood blown out of the nose, mouth, or wound.

- **Transfer or Contact Bloodstains**
  - These patterns are created when a wet, bloody object comes in **contact** with a target surface; may be used to identify an **object** or **body** part.
  - A **wipe** pattern is created from an object moving through a bloodstain, while a **swipe** pattern is created from an object leaving a bloodstain.

Images from http://www.bloodspatter.com/BPATutorial.htm
THE TYPES OF SPATTER

IMPACT SPATTERS

LOW-VELOCITY
FORCE OF IMPACT: 5 feet per second (fps) or less
DROPLET DIAMETER: 4-8mm
POSSIBLE SOURCE: dripping blood, “passive spatters”

MEDIUM-VELOCITY
FORCE OF IMPACT: 5-100 fps
DROPLET DIAMETER: less than 4mm
POSSIBLE SOURCE: blunt object, fist, stabbing, artery spray

HIGH-VELOCITY
FORCE OF IMPACT: >100fps
DIAMETER: less than 1mm
POSSIBLE SOURCE: gunshot wounds
OTHER BLOODSTAIN PATTERNS

**CAST-OFF STAINS**
When blood on an object that is swung through space flies off onto a surface.

**SHADOWING/ GHOSTING**
When there is an empty space, or "void" in spatter, indicating that an object blocked spray.

**SWIPES AND WIPES**
Swipes occur when blood on a surface is smeared, and wipes occur when a bloody object brushes against a surface.

**EXPIRATORY BLOOD**
Blood that is coughed up or breathed out. Misty pattern resembling high-velocity spatter results.

**TRANSFER PATTERN**
The bloodstain pattern left on a surface after a bloody object has been placed on it.
Semen Testing

2.5 to 6 ml of seminal fluid are released during ejaculation. Each ml contains about 100 million sperm. That’s a total of 600 million sperm, each with its own set of DNA.
Testing for Semen

- **Acid Phosphatase Color Test**
  - Acid phosphatase is an enzyme secreted by the prostate gland that is released into semen. By adding a sodium alpha naphthylphosphate and Fast Blue B dye. This test is done on filter paper and gives a purple color.

- **MUP**
  - Causes semen to glow in UV light. A reaction in less than 30 seconds is a positive result.
Testing for Semen

- Presence of sperm
  - Oligospermia—low sperm count
  - Aspermia—lack of sperm (usually the result of a vasectomy)
- PSA (prostate specific antigen) chemical that definitively proofs that a sample is semen.
Collecting Rape Evidence

- Rape Kit p. 355
- Fully motile, intact sperm usually indicate that intercourse took place within 4 to 6 hours.
- Intact sperm are usually not found after 16 hours but in some cases have been found up to 72 hours later.
- Nonmotile sperm can be found for 3 to 6 days.
- PSA is not detectable after 24 hours.