# Blood

<table>
<thead>
<tr>
<th>Component</th>
<th>Structure</th>
<th>Functions</th>
</tr>
</thead>
</table>
| Plasma    | Water containing many substances in solution | 1. Liquid medium in which cells and platelets can float.  
2. Transports CO\(_2\) in solution.  
3. Transports food materials in solution.  
4. Transports urea in solution.  
5. Transports hormones in solution.  
6. Transports heat.  
7. Transports substances needed for blood clotting.  
8. Transports antibodies. |
| Red Cells | Biconcave discs, no nucleus, contains haemoglobin | 1. Transports oxygen.  
2. Transports small amounts of CO\(_2\). |
| White Cells | Variable shape with nucleus | 1. Engulf and destroy bacteria (phagocytosis).  
2. Make antibodies. |

If a test tube of blood was centrifuged at high speed, it would look like this:

![Diagram of blood components after centrifugation](attachment:image.png)
Plasma

Transports - cells
- ions (iron for haemoglobin and calcium for strong bones)
- plasma protein (fibrinogen for blood clotting)
- hormones
- urea
- CO₂
- vitamins
- soluble digested food molecules (e.g. fatty acids, glycerol etc.)

<table>
<thead>
<tr>
<th>Red blood cells</th>
<th>Platelets</th>
<th>White blood cells</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 million/mm³</td>
<td>300,000/mm³</td>
<td>5,000/mm³ - varies</td>
</tr>
<tr>
<td>No nucleus</td>
<td>No nucleus</td>
<td>Nucleated</td>
</tr>
<tr>
<td>Lasts for 3 months</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Has a biconcave shape</td>
<td>Cannot be seen under a light microscope</td>
<td>Lymphocytes: produce antibodies</td>
</tr>
<tr>
<td>side view</td>
<td></td>
<td>Phagocytes: engulf bacteria</td>
</tr>
<tr>
<td>top view</td>
<td></td>
<td></td>
</tr>
<tr>
<td>indent</td>
<td></td>
<td>Defence against disease</td>
</tr>
</tbody>
</table>

Transports oxygen using haemoglobin

To make blood smear

1. Take a slide
2. Put a drop of blood in the centre
3. Then add Leishman’s stain.
4. Spread the blood and the stain with another slide
5. Let it dry
6. If you look at it through a microscope, you will see red blood cells or white blood cells. The white blood cells will be blue because of the Leishman’s stain. Platelets cannot be seen, as they are too small.
Red blood cells

- Most numerous cell in the blood
- Biconcave shape (on side view) and circular (from top).
- Very thin (8 microns (\(\mu\)) (0.008mm))
- Flexible
- Therefore, can be forced into capillaries in single file and thus leaving large surface area for exchange with adjacent tissues
- Hollow on either side – increasing surface area for uptake of oxygen
- No nucleus and so can carry more haemoglobin and therefore more oxygen
- Without nutrients they only last three months so they are manufactured in certain bone marrow
- No mitochondria – so that they do not use up the oxygen which they are carrying

Haemoglobin (Hb)

- An ion containing red pigment
- Four iron groups
- Each combines with a molecule of O\(_2\)
- Hb combines with O\(_2\) where it is plentiful (e.g. lungs or gills in fish) and releases O\(_2\) where it is scarce (e.g. in brain/muscle cells)
- Hb + 4O\(_2\) \(\rightarrow\) HbO\(_8\) (oxyhaemoglobin)

White blood cells

- Have nucleus
- Capable of moving out of thinnest blood vessels to combat infection
- Phagocytosis (engulf bacteria)
- Lymphocytes (produce antibodies)
- Number increases during infection or disease

Platelets

- Very small – not see under a light microscope
- Irregular shape
- Important in blood clotting process.

When a blood vessel is cut, the damage to the platelets and/or exposure of the platelets to the air sets off a chain of reactions leading to blood clotting.
Damage to platelets/exposure of platelets to air causes a number of reactions including several clotting steps:

**Explanation of above diagram:**

Damage to the platelets/exposure of the platelets to the air causes Prothrombin to change into Thrombin using Ca\(^{2+}\), Factor VIII and Thrombokinase. Thrombin causes Fibrinogen to turn into Fibrin, which forms a clot.

All items in boxes are contained in body already. Others are caused by the steps above.

**Summary – functions of the blood**

1. **Transport:**
   - (a) cells
   - (b) soluble products of digestion
   - (c) antibodies
   - (d) waste products
   - (e) hormones
   - (f) mineral ions

2. **Temperature regulation:**
   - (a) **vasodilation** (heat loss increase) increase in blood supply to surface capillaries, so blood capillaries are more prominent: increase in surface area for heat loss.
   - (b) **vasoconstriction** (heat loss decrease) reduced blood supply to surface capillaries, so blood capillaries are less prominent and so less surface area from which heat is lost.

3. **Defence:**
   - (a) Phagocytes
   - (c) Lymphocytes
   - (d) Blood Clotting

4. **Erection of the penis.**
Carriage of CO₂

- CO₂ produced by cells in respiration
- Diffuses out of cells into blood plasma
- In blood, CO₂ is transported in 3 ways:
  - 85% in plasma as sodium bicarbonate
  - 5.1% by Haemoglobin
  - 5% as carbonic acid

Circulation of blood

Experiment: *Investigate the blood flow in the vein of an arm:*

1. Grip a stick
2. Tie a bandage around the upper part of the arm.
3. Observe vein standing out
4. Place two fingers across the prominent vein. Observe
5. Then remove upper finger
6. Replace upper finger and remove lower finger. Observe.

Circulation of blood flow in the arm:

1. Blood flows back to the heart from the hand to the shoulder.
2. Blood flows in vessels close to the surface of the skin.
3. Swellings which appear in the experiment are due to the presence of valves, which stop the backflow of blood where the pressure is low.

Circulation

The heart is an organ made of muscle tissue. It has two pumps, side by side, which makes the heart a complex pump.

![Heart Diagram]

The heart helps move the blood around the body and to the lungs. The heart muscle has its own blood supply provided by the coronary vessels.

Living muscle cells require glucose and oxygen in order to respire, produce energy and contract.
The heart has four chambers of equal volume.

2 Atria (left and right) - receiving chambers
thin walled

Right Atrium: receiving vena cava (from head and body)
blood rich in CO₂, low in O₂

Left Atrium: receiving pulmonary vein (from lungs)
rich in O₂

2 Ventricles - pumping chambers
thick muscular walls to create high pressure

Right ventricle: pumps blood to lungs via pulmonary vein
blood rich in CO₂, low in O₂

Left Ventricle: pumps blood to the head and the body via the aorta
blood rich in O₂
muscular wall much thicker than right ventricle as it has to pump
the blood around the whole body.
Tendons: prevent valves turning inside out when ventricle contracts. They are attached to muscular bumps on the inside wall of the ventricle. They are **non-elastic**

**To ensure the one-way flow of blood:**

1. **Ventricles:** pumping organs
   thick muscular walls (left thicker than right)

2. **Valves:**
   (a) Mitral – prevent backflow of blood when ventricles contract
       (i) Tricuspid (right atrium/ventricle)
       (ii) Bicuspid (left atrium/ventricle)
   (b) Semi-lunar/pocket valves - found in the pulmonary artery and aorta (only valves in arteries – normally the pressure is too high)
      - prevent backflow of blood into ventricles when ventricles relax.

3. **Veins:** possess semi-lunar valves
   prevent backflow of blood where pressure is low
Heartbeat

- Controlled by a single pacemaker
- Situated in top of right atria
- Causes atria to contract together
- Ventricles contract base upwards
- Tissue in middle of heart slows electric impulses

To detect heartbeat and find heart rate

- Fingers on radial (wrist/neck) artery
- Count number of beats per minute
- Normal heart rate = average of large sample of people of: same gender, age and health.

<table>
<thead>
<tr>
<th></th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asleep</td>
<td>60-65</td>
<td>Slightly higher</td>
</tr>
<tr>
<td>At rest</td>
<td>78</td>
<td>84</td>
</tr>
</tbody>
</table>

Heart rate increases with:
- Exercise
- Excitement
- Increase in body heat

Heart rate decreases with:
- Sleep
- Advancing age

An increase in muscular action causes a rise in muscular oxygen and glucose demands. Therefore, the heart rate increases to supply the oxygen and glucose at a faster rate and to remove CO\(_2\) and lactic acid.
### Blood Vessels

#### Artery
- **elastic tissue**
- lumen
- muscle layer

#### Vein
- **elastic tissue**
- lumen
- muscle layer

#### Capillary
- 1 cell thick
- nucleus
- red blood cell (approximate scale)

<table>
<thead>
<tr>
<th>Artery</th>
<th>Vein</th>
<th>Capillary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thick muscular wall</td>
<td>Thin muscular wall</td>
<td>1 cell thick – no muscular wall</td>
</tr>
<tr>
<td>Highly elastic</td>
<td>Not very elastic</td>
<td>No elastic layer</td>
</tr>
<tr>
<td>Not permeable</td>
<td>Not permeable</td>
<td>Permeable – leaky</td>
</tr>
<tr>
<td>Small Lumen</td>
<td>Large lumen</td>
<td>Lumen – 1 cell thick</td>
</tr>
<tr>
<td>High blood pressure</td>
<td>Low blood pressure</td>
<td>Blood pressure dissipated – low blood pressure</td>
</tr>
<tr>
<td>Blood moving away from heart</td>
<td>Blood moving towards heart</td>
<td>Blood between arteries and veins</td>
</tr>
<tr>
<td>No valves (except aorta and pulmonary artery)</td>
<td>Valves present</td>
<td>No valves</td>
</tr>
<tr>
<td>High in oxygen – except pulmonary artery</td>
<td>Low in oxygen – except pulmonary vein</td>
<td>Varied: gain in CO₂ and loss of oxygen due to tissues.</td>
</tr>
</tbody>
</table>

Deep in tissue for protection | | Gaps in cells to allow white cells out |
**Order in which blood flows**

- Artery
- Arteriole (small Artery)
- Capillary
- Venule (small vein)
- Vein

**Heart Disease**

There are many factors, which can cause heart disease. In most cases, it is a combination of them.

(a) **inherited tendency**

However, there have been an increase in heart disease in recent years particularly in the West. So, it is unlikely to be solely inherited.

(b) **Smoking**

Statistics show that it is two to three times more likely. It is believed that it is chemicals, which damage the inside lining. Fat deposits lead to Atheroma. Atheroma causes blood vessels to narrow, which in turn causes strain on the heart.

(c) **Fatty diet**

Atheroma includes cholesterol. More cholesterol means more likeliness to get a heart attack.

(d) **Stress**

Increase in blood pressure caused by stress strains the heart. This increases the likeliness to get Atheroma.

(e) **lack of exercise**

Vigorous exercise improves blood circulation in blood vessels.
### Heart Attacks

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thrombosis</td>
<td>blood clot in system. Often occurs if someone is still for a long time. If there is thrombosis in the brain, it is known as a stroke. It is most serious if it is in the brain or the heart.</td>
</tr>
<tr>
<td>Coronary Thrombosis</td>
<td>blood clot in coronary artery or any other muscle in the heart.</td>
</tr>
<tr>
<td>Angina</td>
<td>early stages of atheroma – little blood reaching the heart. Angina is the pain in the chest caused by light exercise or exertion. This is a warning that the person should be careful to avoid a coronary heart attack. Angina is the partial blocking in the system.</td>
</tr>
<tr>
<td>Artificial Pacemaker</td>
<td>This is a small electronic device that is implanted in the abdomen which produces electronic impulses which stimulates the ventricles to contract at the right rate.</td>
</tr>
<tr>
<td>Normal Pacemaker</td>
<td>Specialised muscle cells at the top of the right atrium. It controls the heart rate by nerves from the brain.</td>
</tr>
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The heart is myogenic – this means that it contracts automatically, but the amount varies. The pacemaker adjusts the contracting.

![Pacemaker Diagram](#)

The pacemaker sends impulses through the atria. There is a nerve in the middle of the heart which lets the impulse through. This does not happen straight away, so that it ensures the emptying of the arteries.