

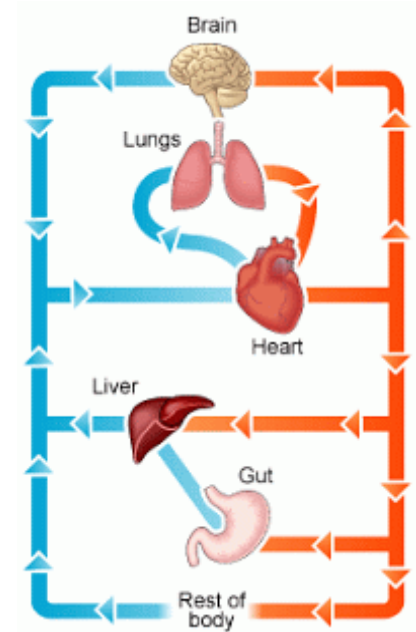
07 – Human transport Biology Notes IGCSE Cambridge 2014

#69 Transport in humans - the circulatory system

The main transport system of human is the **circulatory system**, a system of tubes (**blood vessels**) with a pump (the **heart**) and **valves** to ensure **one-way** flow of blood.

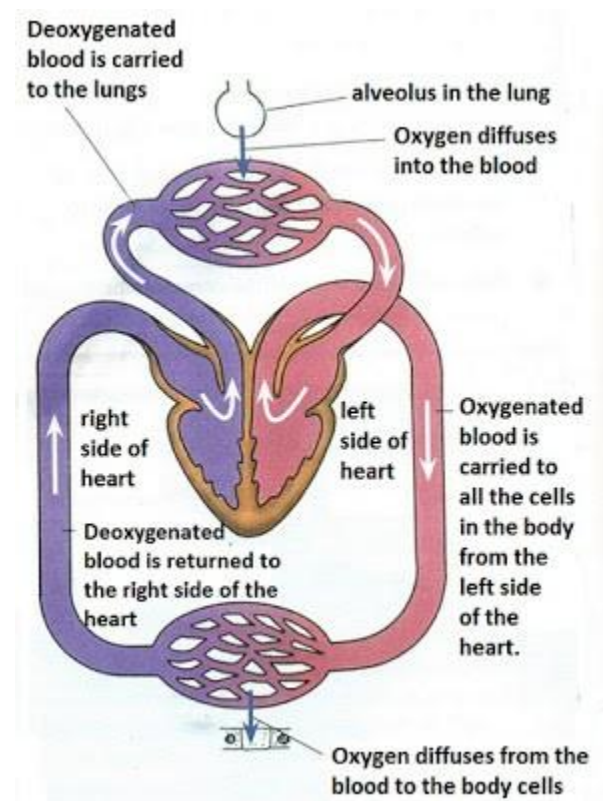
Its functions:

- To transport **nutrients** and **oxygen** to the cells.
- To remove **waste** and **carbon dioxide** from the cells.
- To provide for efficient **gas exchange**.



The **right** side of the heart collects **deoxygenated** blood from the body and pumps it to the **lungs**.

The **left** side collects **oxygenated** blood from the lungs and pumps it to the **body**.

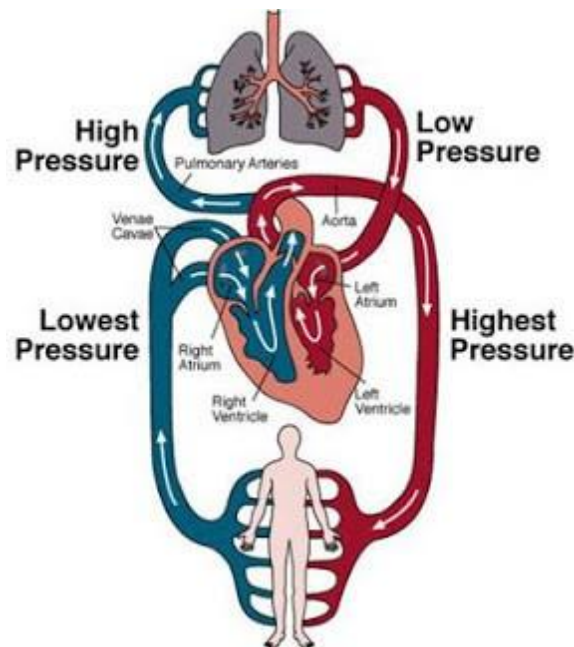


The double circulation

Beginning at the lungs, blood flows into the left-hand side of the heart, and then out to the rest of the body. It is brought back to the right-side of the heart, before going back to the lungs again.

This is called a **double circulation system**, because the blood travels through the heart twice on one complete journey around the body:

- one circuit links the **heart** and **lungs** (low pressure circulation)
- the other circuit links the **heart** with the rest of the **body** (high pressure circulation).



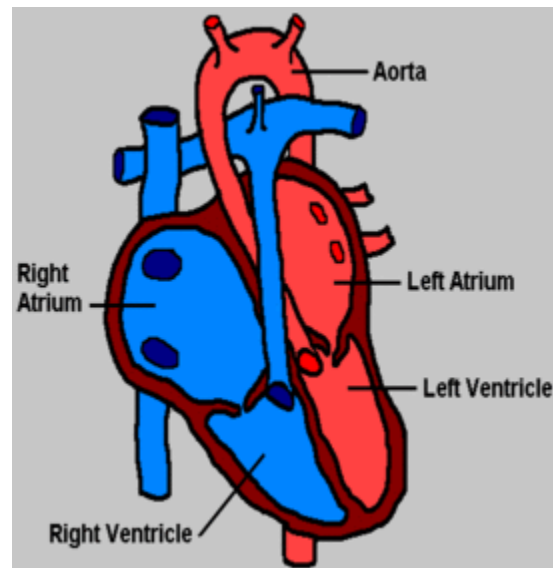
The importance of a double circulation

- **Oxygenated** blood is kept separate from **deoxygenated** blood. The septum in the heart ensures this complete separation. Oxygenated blood flows through the left side of the heart while deoxygenated blood flows through the right.
- The **blood pressure** in the **systemic circulation** is kept **higher** than that in the pulmonary circulation. The left ventricle, with a thicker wall, pumps blood under higher pressure to the body and delivers oxygenated blood effectively to all parts of the body. The right ventricle has a thinner wall and pumps blood to the lungs under lower pressure, thereby avoiding any lung damage.

Video Circulatory system

https://www.youtube.com/watch?v=oE8tGkP5_tc

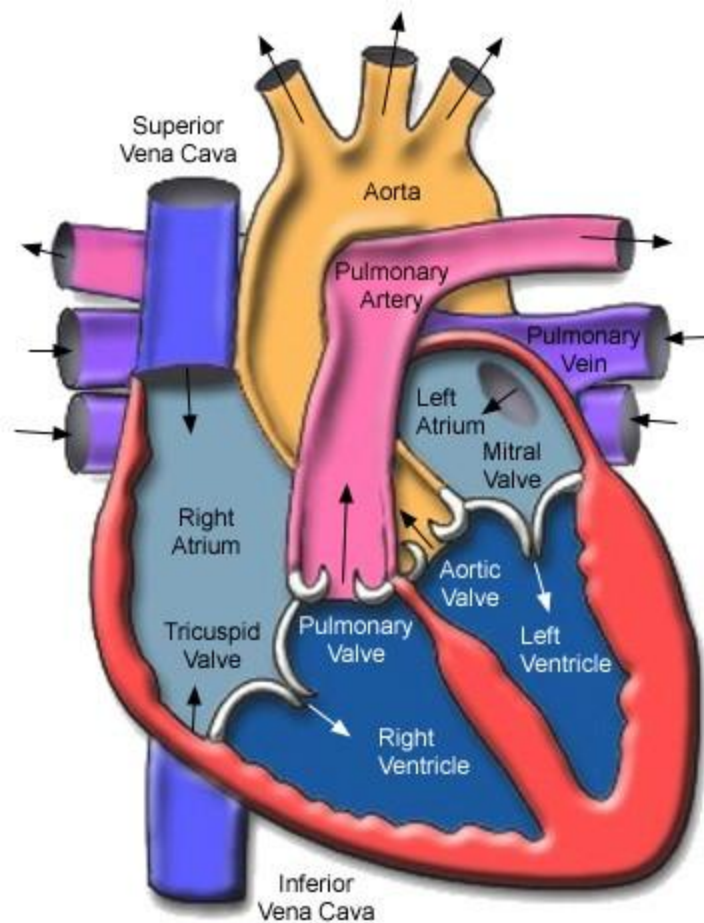
#70 Structure and function of the heart



The function of the **heart** is to pump blood around the body. The **right** side pumps blood to the **lungs** and the **left** side pumps blood to the rest of the **body**.

Structure of the heart

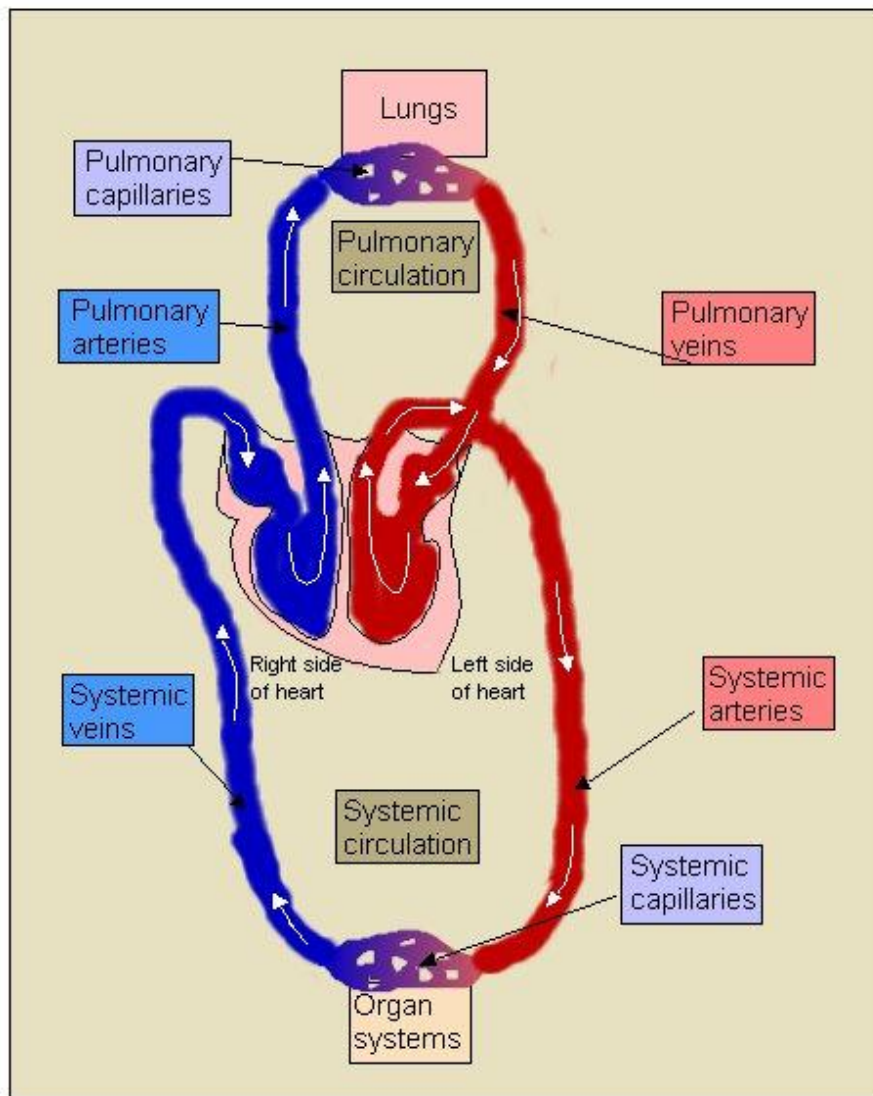
Muscular wall	Septum	Chambers	Valves	Associated blood vessels
The wall of the LV is much thicker than the RV because it needs to build up enough pressure to move the blood to all the main organs.	Completely separated the chambers on the left-hand side and the ones on the right-hand side.	2 atria: right atrium (RA) and left atrium (LA), receiving blood from veins and squeeze it into the ventricles. 2 ventricles: right ventricle (RV) and left ventricle (LV), receiving blood from the atria and squeeze it into arteries.	Semilunar Tricuspid Bicuspid	Vena cava Pulmonary artery Pulmonary Aorta



Heart's function

- **Blood circulation**

1. Blood in the **right ventricle** (RV) is pump to the **lungs**
2. Blood from the **lungs** flows back into the **left atrium** (LA) and then into the **left ventricle** (LV).
3. Blood in the LV is pumped through the **body** (except for the lungs)
4. Blood returns to the heart where it enters the **right atrium** (RA).



- **Muscular contraction**

The heart is made of a special type of muscle called **cardiac muscle** which contracts and relaxes regularly, throughout life.

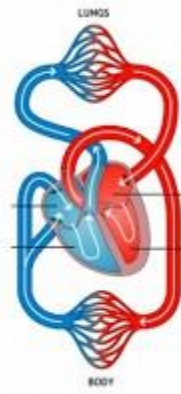
The heart's muscle is constantly active, so it needs its own blood supply, through the **coronary artery**, to provide it with **oxygen** and **glucose**.

- **Working of the valves**

Valves in the heart prevent blood from being pushed backwards up into the atria when the heart 'beats'.

Animation: [Heart Contraction and Blood Flow](#)
[How the heart pumps blood](#)

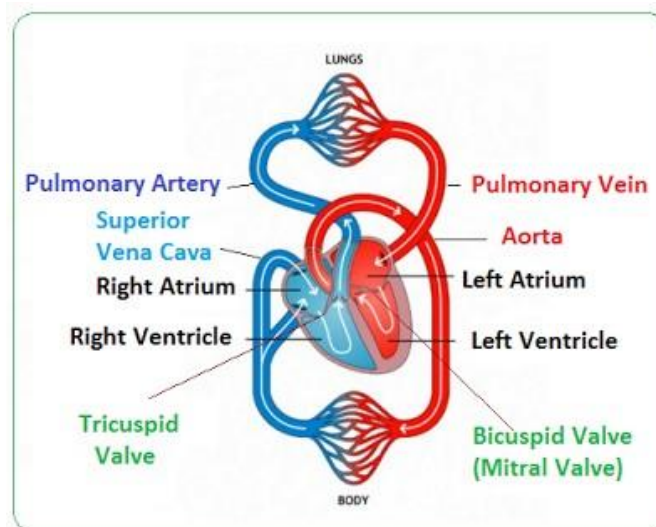
Try this



1. On a copy of the diagram of the double circulatory system, label:
 - i) The 4 main blood vessels (4 marks)
 - ii) The chambers of the heart (4 marks)
 - iii) The 2 valves shown (2 marks)
2. State 2 differences in composition between blood leaving the right ventricle and blood entering the left atrium. (2 marks)

Answers:

1.



2. Blood leaving the right ventricle has more CO_2 and less O_2 than blood entering the left atrium.

Common misconceptions

Remember that blood passing through the chambers of the heart does **not** supply the heart muscle with oxygen or glucose. The heart muscles has its own blood supply - via the coronary arteries - to do this.

#71 Effect of exercise on heartbeat and causes of coronary heart disease

A heartbeat is a contraction. Each contraction squeezes blood to the lungs and body. The heart beats about **70 times** a minute, more if you are younger, and the rate becomes lower the fitter you are.

- During exercise the **heart rate increases** to supply the muscles with more oxygen and glucose → allow the muscles to respire aerobically → they have sufficient energy to contract.
- **Regular exercise** is important to keep the heart muscle in good tone → heart is more efficient in maintaining blood pressure and ↓ risk of coronary heart disease and stroke.



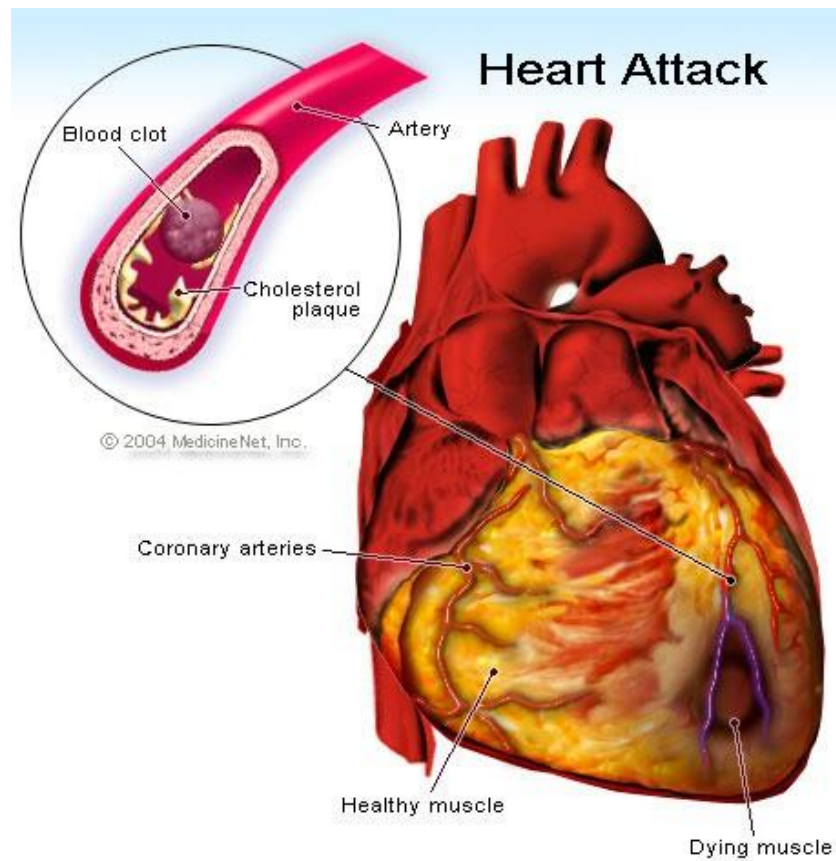
Coronary arteries

The muscles of the heart are so thick that the nutrients and oxygen in the blood inside the heart would not be able to diffuse to all the muscles quickly enough. The heart muscles need a constant supply of nutrients so that it can keep contracting and relaxing. The **coronary arteries** supply this.

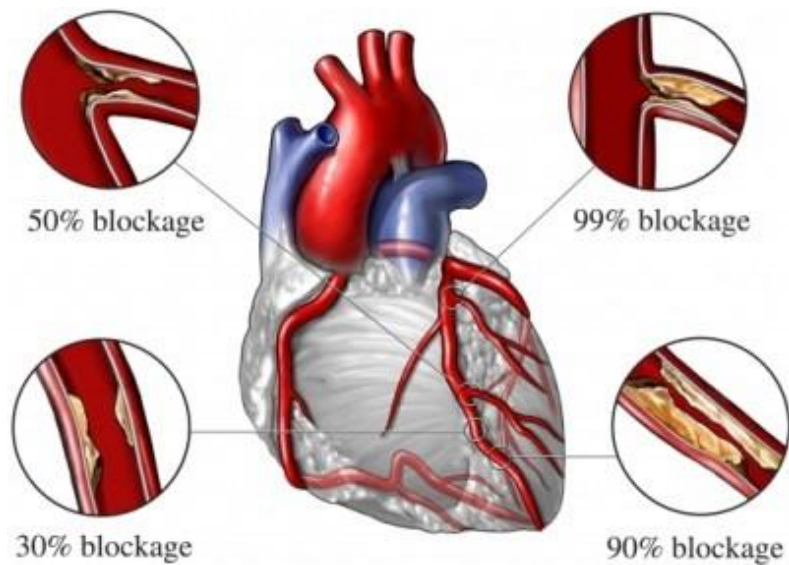
If a coronary artery gets **blocked** – e.g. by a blood clot – the cardiac muscles run **short of oxygen** → they can not respire → can not obtain energy to contract → **heart stops** beating. This is called a **heart attack** or **cardiac arrest**.

Main causes of a coronary heart disease and preventive measures

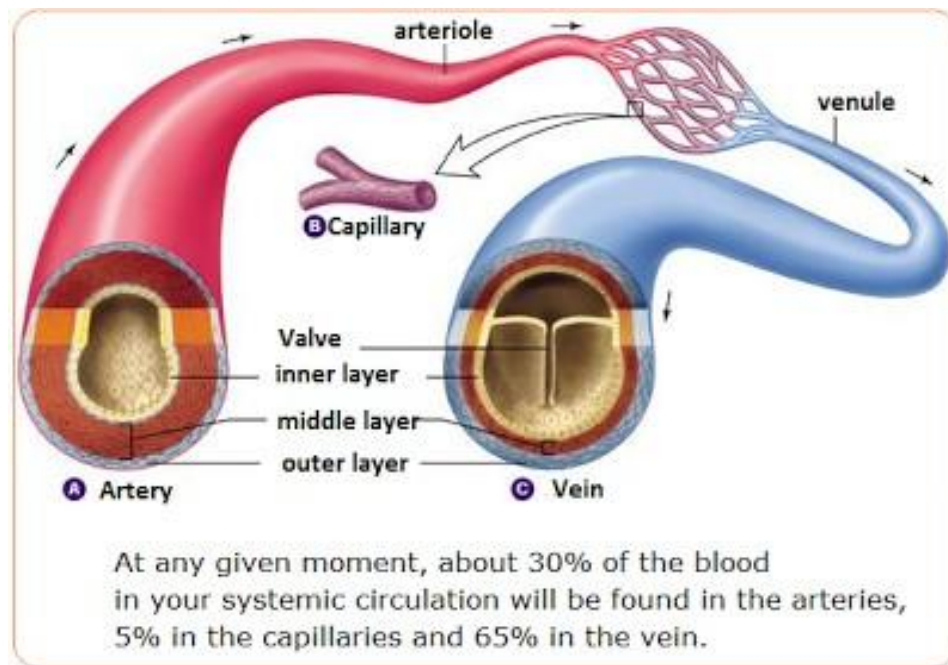
Cause	Explanation	Preventive measures
Poor diet with too much saturated (animal) fat	→ Cholesterol building up in arteries → block the blood vessels/form a blood clot.	Cholesterol - free diet
Smoking	Nicotine damages the heart and blood vessels	Stop smoking
Stress	Tends to ↑ blood pressure → collect fatty materials in the arteries.	Relaxing Avoid the causes of stress
Obesity	→ put extra strain on the heart, makes it more difficult for the person to exercise.	Controlled diet Regular exercise
Lack of exercise	The heart muscle loses its tone and becomes less efficient in pumping blood.	Regular exercise
Inherited factors	Heart disease can pass from one generation to the next in some families.	Reduce the other risk factors by a healthy life-style.



Blockage of the coronary arteries is called **coronary heart disease**.



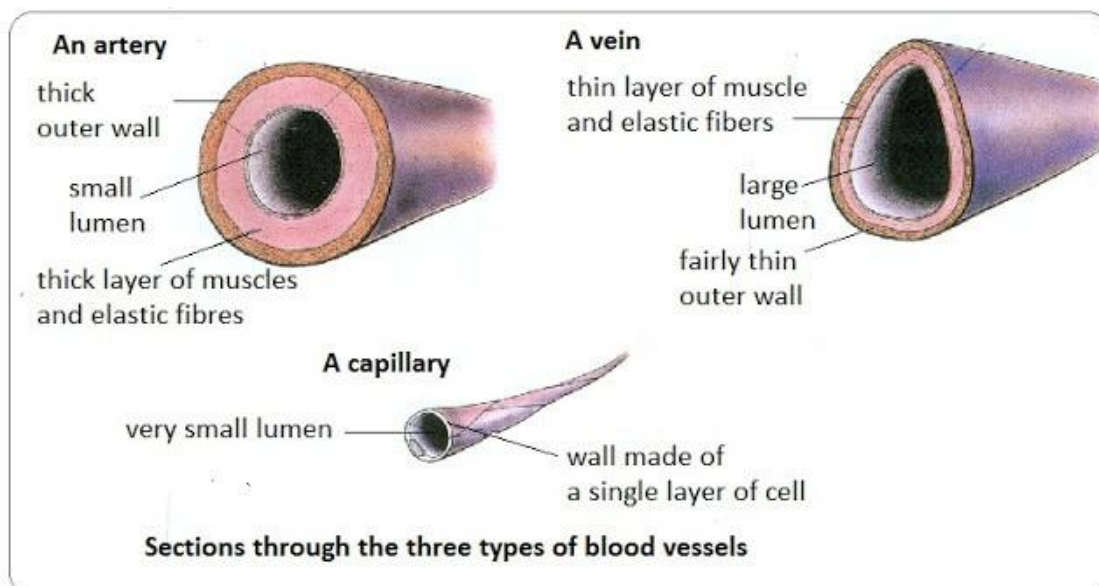
#72 Arteries, veins and capillaries - structure and functions



There are 3 main kinds of blood vessels – arteries, veins and capillaries.

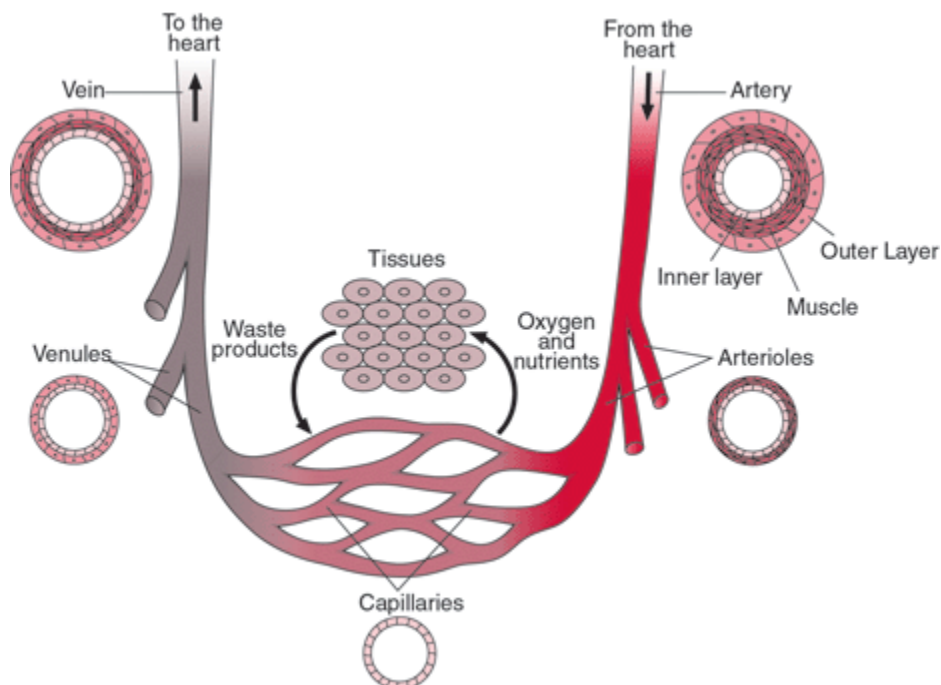
- **Arteries** carry blood away from the heart. They divide again and again, and eventually form very tiny vessels called capillaries.
- The **capillaries** gradually join up with one another to form large vessels called veins.
- **Veins** carry blood towards the heart.

The comparison of blood vessels structure and functions



	Arteries	Capillaries	Veins
Function	Carry blood away from the heart at high pressure	-Supply all cells with their requirements -Take away waste products	Return blood to the heart at low pressure
Structure of wall	- Thick , strong -Contain muscles , elastic fibres and fibrous tissue	Very thin , only one cell thick	- Thin -Mainly fibrous tissue -Contain far less muscle and elastic tissue than arteries
Lumen	- Narrow -Varies with heartbeat (increases as a pulse of blood passes through)	- Very narrow -Just wide enough for a red blood cell to pass through	Wide
Valves	(-)	(-)	(+) Prevent backflow
How structure fits function	-Strength and elasticity needed to withstand the pulsing of the blood, prevent bursting and maintain pressure wave -Helps to maintain high blood pressure , preventing blood flowing backwards	- No need for strong walls, as most of the blood pressure has been lost -Thin walls and narrow lumen bring blood into close contact with body tissue, allowing diffusion of materials between capillary and surrounding tissues. -White blood cells can squeeze between cells of the wall	- No need for strong walls, as most of the blood pressure has been lost - Wide lumen offers less resistance to blood flow

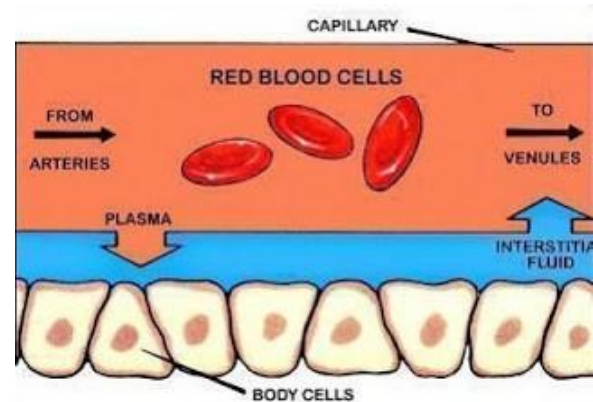
The transfer of materials between capillaries and tissue fluid



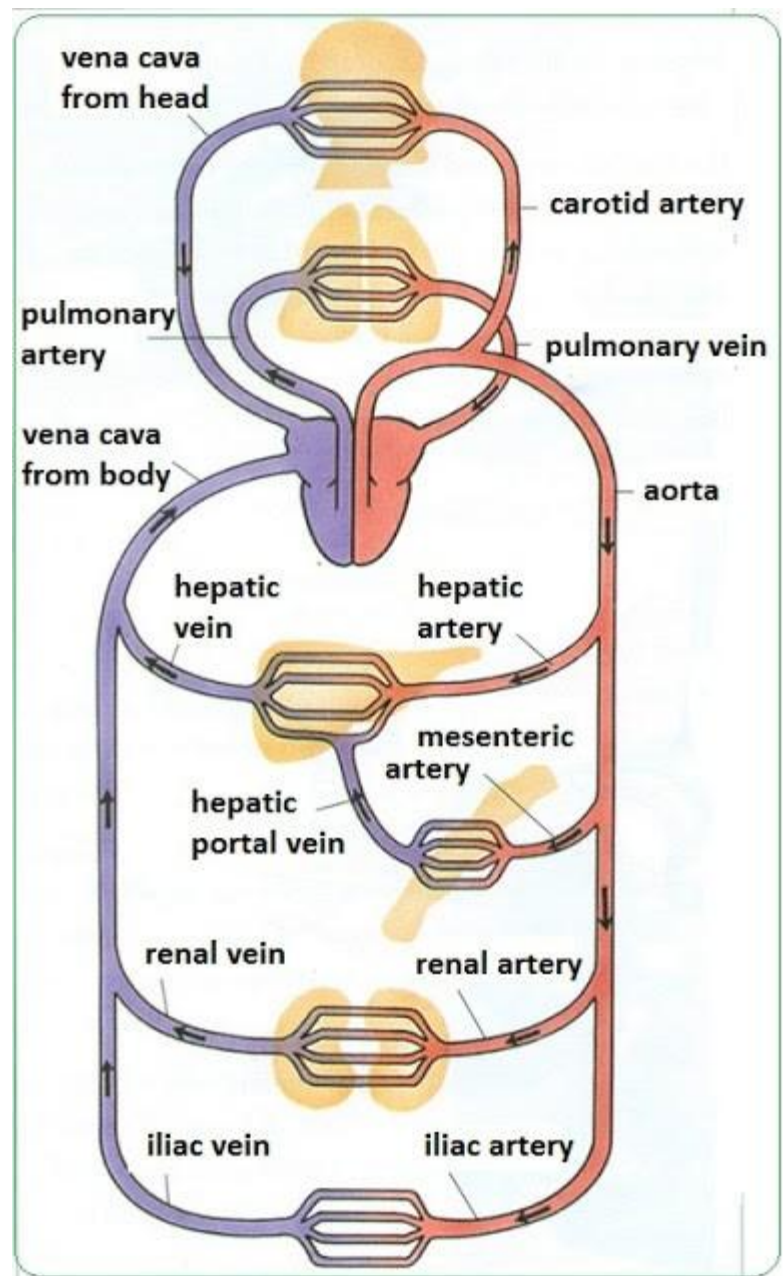
As blood enters capillaries from arterioles (small arteries), it slows down. This allows **substances** in the plasma, as well as **O₂** from red blood cells, to **diffuse** through the capillary wall into the surrounding tissues (the capillary wall is thin and permeable).

Liquid in the **plasma** also passes out. This forms **tissue fluid**, bathing the cells. **Waste products** from the cells, e.g. CO₂, **diffuse** back through the capillary walls into the plasma. Some of the tissue fluid also passes back.

Diffusion is responsible for the transfer of materials between capillaries and tissue fluid.



Plan of the main blood vessels in the human body



Sample questions

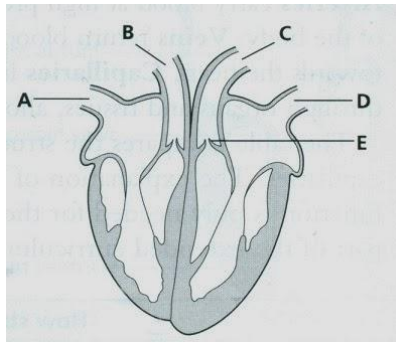


Figure above shows a section through the heart

- i) Name the two blood vessels **A** and **B** [2 marks]
- ii) Which of blood vessels **A**, **B**, **C** or **D** carry oxygenated blood [1 mark]
- iii) Name valve **E** and state its function [3 marks]

Student's answer

- i) A, vena cava (✓) B, pulmonary vein (✗)
- ii) C (✗)

iii) name: semilunar valve (✓) function: to stop blood going backwards (✓)

Examiner's comments

*Blood vessels **B** is the pulmonary artery. Arteries of the heart always carry blood from a ventricle.*

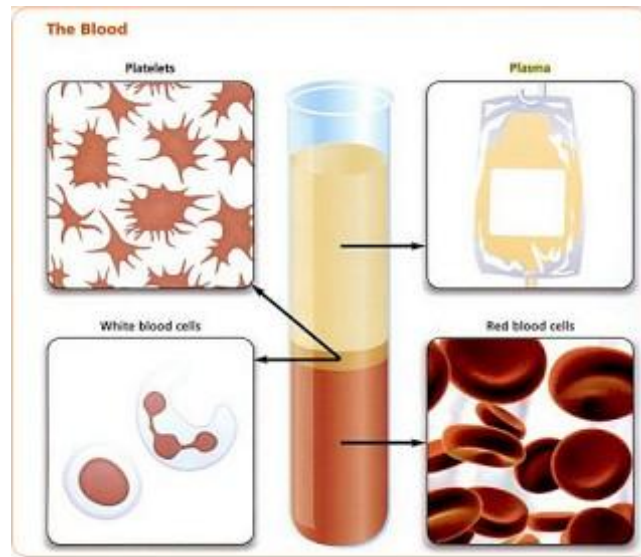
*Part ii) needs two answers (blood vessels **C** and **D**) to gain the mark.*

***D** is the pulmonary vein, which carries oxygenated blood to the heart from the lung.*

***C** is the aorta, which carries oxygenated blood from the heart to the body.*

In part iii) the name of the valve is correct, but there are two marks for its functions. This candidate has given only one statement: a second mark was available for stating that the valve prevents blood from going back into the left ventricle.

#73 Blood composition and Plasma

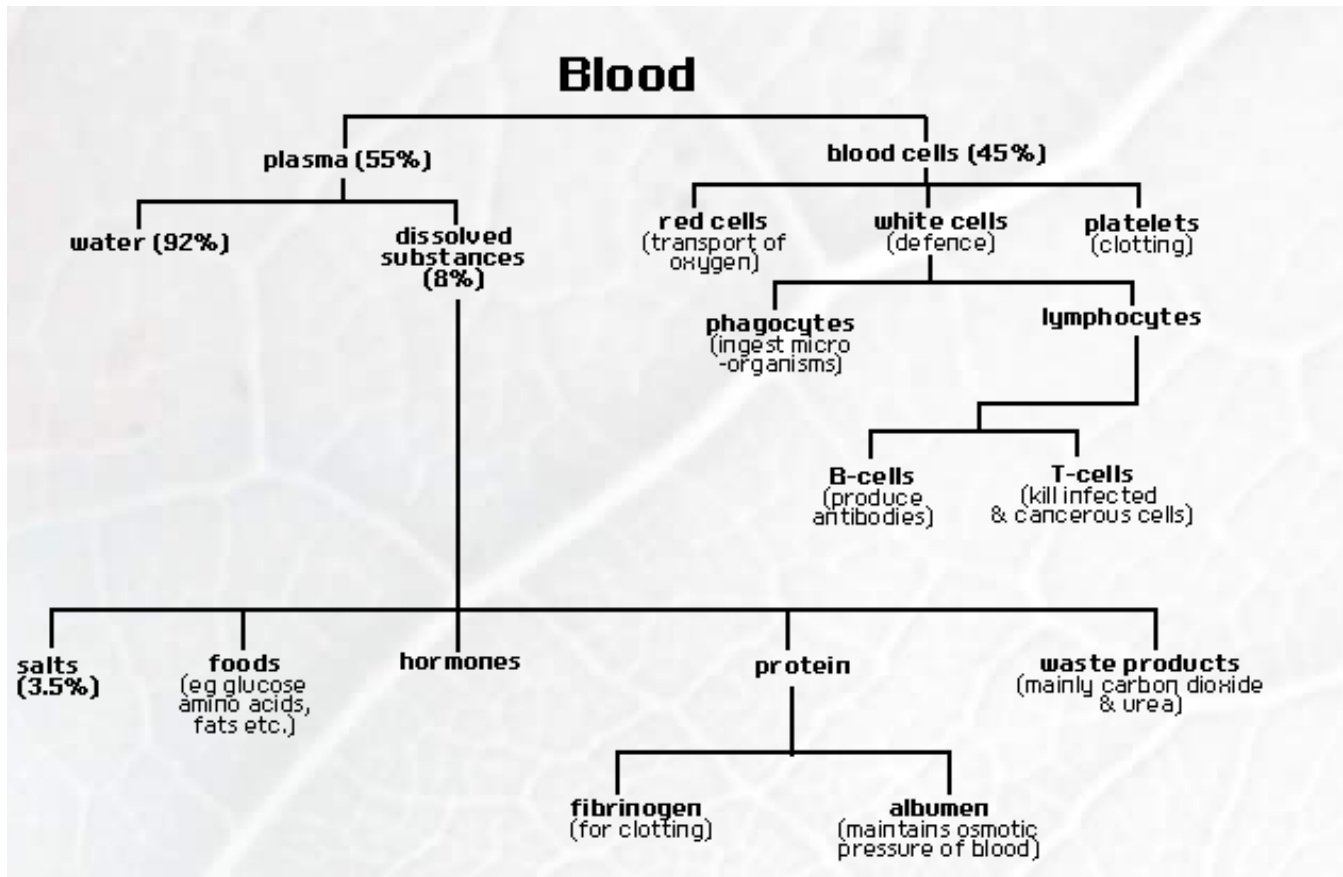


If blood is allowed to stand without clotting, it separates out into 4 components: **plasma**, **red blood cells**, **white blood cells** and **platelets**.

The **plasma** and **red** blood cells play an important role in the **transportation** of substances, around the body.

White blood cells and **platelets** are part of the body's **immune system**.

55% of the blood is plasma. This straw-coloured liquid contains water with many important **dissolved** substances which must be carried around the body. **Most materials** are **carried** by the blood plasma, **except** for **oxygen**.



Credit: [moodle](#)

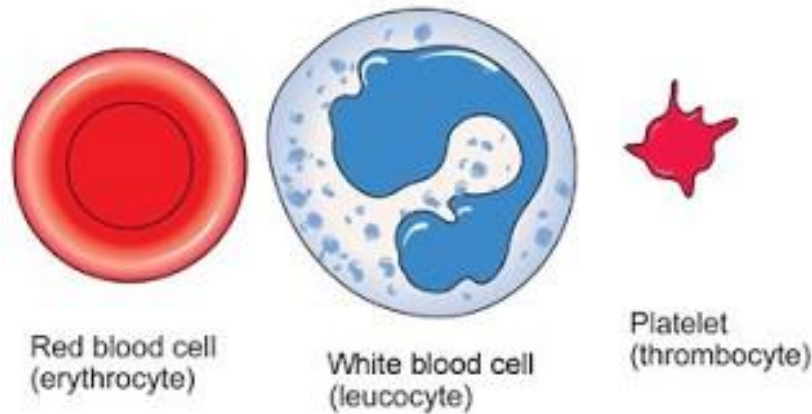
Plasma transports:

- blood **cells**
- soluble **nutrients** e.g. **glucose** (products of digestion) from the small intestine to the organs
- **amino acids** (plasma acts as a pool for amino acids for these cannot be stored in the body)
- **plasma proteins** that are important in blood **clotting** (e.g. fibrinogen).
- **CO₂** (waste gas produced by respiration in cells) from the organs to lungs
- Other wastes of digestion (e.g. **urea**) from the liver to the kidneys.
- **Antibodies** and **antitoxins**
- **Hormones**
- **Ions**
- **Heat** from the liver and muscles to all parts of the body.

Video What is blood?

https://www.youtube.com/watch?v=CRh_dAzXuoU

#74 Blood cells - structure and functions



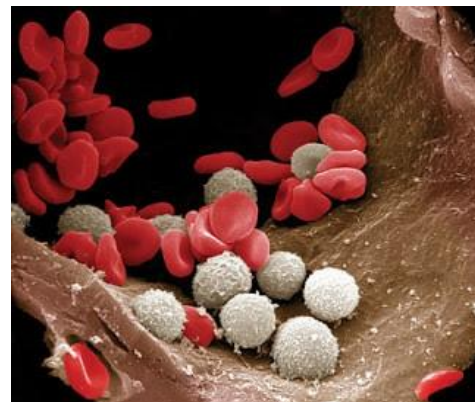
Blood consists of **cells** floating in **plasma**.

Most of the cells are **red blood cells**.

A much smaller number are **white blood cells**.

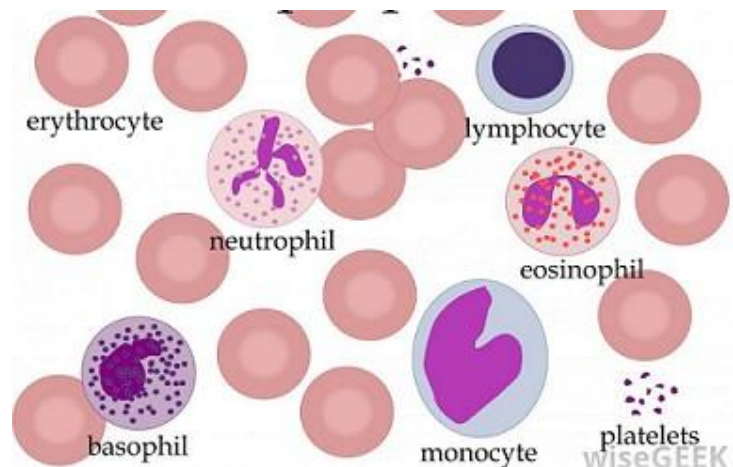
There are also fragments formed from special cells in the bone marrow, called **platelets**.

Red and **white** blood cells as seen under a light microscope.



Blood as seen through a microscope:

- The largest cells are **white cells**.
- The others are all **red cells**.
- There are also a few **platelets**.

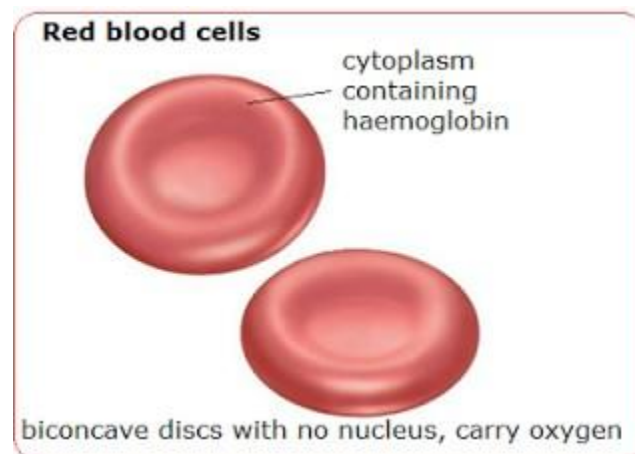


Functions of blood cells

- Red blood cells transport **oxygen**.
- White blood cells protect against **disease**.
- Blood platelets help the blood to **clot**.

1. Red blood cells (erythrocytes)

- Made in the **bone marrow** of some bones, including ribs, vertebrae and some limb bones. Produced at a very fast rate – about 9000 million per hour!
- **Transport** O_2 from lungs to all respiring tissues. Prepare CO_2 for transport from all respiring tissues to lungs.
- Contain **haemoglobin (Hb)**, a red iron-containing pigment which can **carry** O_2 . In the lungs, Hb combines with O_2 to form oxyhaemoglobin. In other organs, oxyhaemoglobin splits up into Hb and O_2



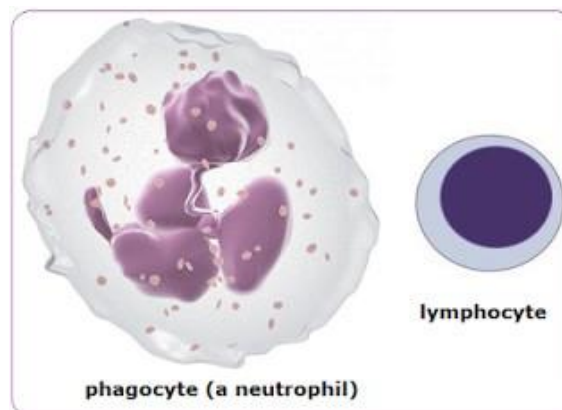
- Have **no nucleus** → can fit more Hb inside the cytoplasm, but can **live** only for about **4 months**.
- Have a special **biconcave disc** shape → increases the surface area and makes the diffusion of oxygen into & out of the cell easier.
- Old red blood cells are broken down in the liver, spleen and bone marrow. Some of the **iron** from the Hb is stored, and used for making new Hb, some of it is turned into bile pigment and excreted.

2. White blood cells (leukocytes)

- Made in the **bone marrow** and in the **lymph nodes**.
- Have a **nucleus**, often large and **lobed**.
- Can **move around** and squeeze out through the walls of blood capillaries into all parts of the body.
- There are many different kinds of white blood cells. They all have the function of **fighting pathogens** (disease-causing bacteria and viruses) and to clear up any dead body cells in your body:

a. Phagocytes:

- Have **lobed nuclei** and **granular cytoplasm**.
- Can move out of capillaries to the site of an infection.
- Remove any microorganisms that invade the body and might cause infection, **engulf** (ingest) and kill them by **digesting** them.



b. Lymphocytes: produce antibodies to fight bacteria and foreign materials.

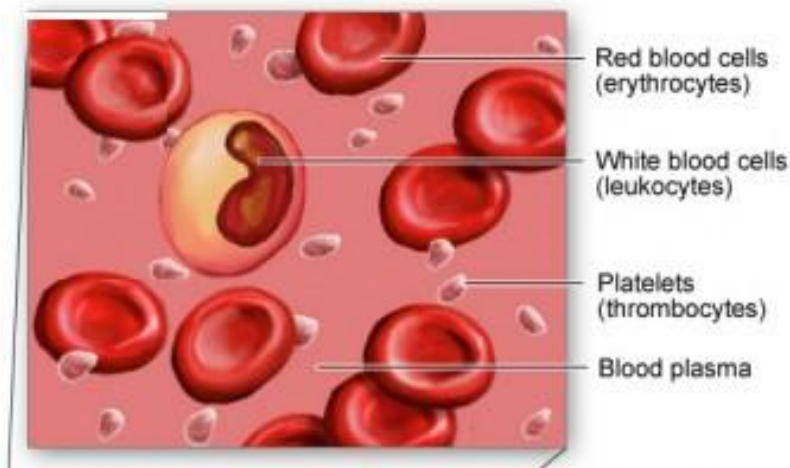
- **Have large nuclei**
- Responsible for **immunity**
- There are two different types of lymphocytes:

B-lymphocytes: secrete special **proteins** called **antibodies** in response to contact with their particular **antigen**, which may be an invading **pathogen** or a **foreign tissue** that has been transplanted.

T-lymphocytes attack **foreign** or **infected** cells and kill them.

3. Platelets (thrombocytes)

- Small fragments of cells, with **no nucleus**.
- Made in the red **bone marrow**.
- Involve in **blood clotting**: form blood clot, which **stop blood loss** at a wound and **prevent** the entry of **germs** into the body.



Functions of the blood

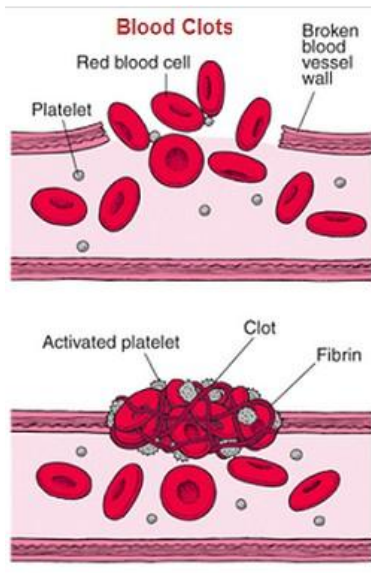
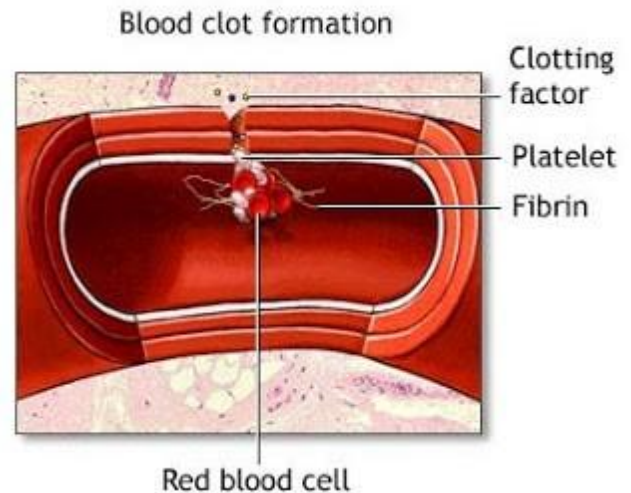
- Transportation of R.B.C's, W.B.C's, oxygen, food nutrients, hormones, and waste products.
- Defence against disease, by white blood cells phagocytosis and production of antibodies.
- Supplying cells with glucose to respire and keep a constant temperature.

#75 Blood clotting

When an injury causes a blood vessel wall to break, platelets are **activated**. They change shape from round to **spiny**, stick to the broken vessel wall and each other, and begin to **plug** the break.

The platelets also interact with **fibrinogen**, a **soluble** plasma **protein**, to form **insoluble fibrin**. **Calcium** is required for that.

Fibrin strands form a **net** that entraps more platelets and other blood cells (red cells and white cells), producing a **clot** that plugs the break.



Necessity for blood clotting

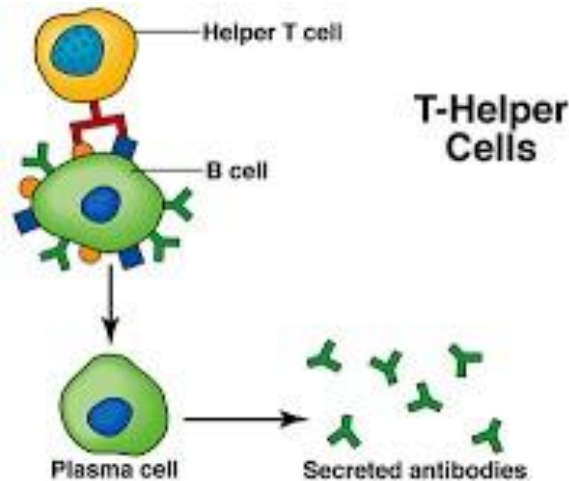
- Prevent excessive blood loss from the body when there is a damage of the blood vessel.
- Maintain the blood pressure.
- Prevent the entry of microorganism and foreign particles into the body.
- Promote wound healing.

Video How does blood clot

<https://www.youtube.com/watch?v=-bZUeb83uU>

#76 Immune system - antibody production, tissue rejection & phagocytosis

The **immune system** is the body's defence against disease and foreign bodies, under the form of **antibody production**, **tissue rejection** and **phagocytosis**.



Antibody production

Antibodies are produced by **lymphocytes**, which are formed in lymph nodes. Lymphocytes produced **antibodies** in response to the presence of **pathogens** such as bacteria. This is because **alien cells** have chemicals called **antigen** on their surface. A different antibody is produced for each antigen.

The antibodies make bacteria **clump** together in preparation for action by **phagocytes**, or neutralise **toxins** produced by the bacteria. Once antibodies have been made, they remain in the blood to provide long-term protection.

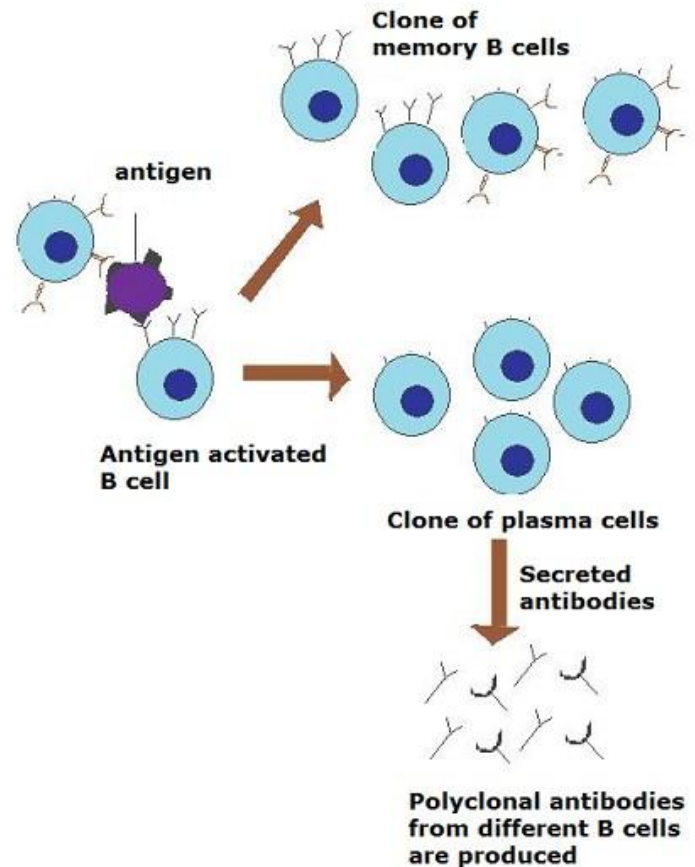
Some lymphocytes **memorise** the antigens the body has been exposed to. They can rapidly reproduce and produce antibodies to respond to further infections by the same pathogen (disease-causing organism).

Tissue rejection

Transplants involve **replacing** a damaged organ with a donor organ. Unfortunately, lymphocytes and phagocytes will respond to any foreign cells in your body, even if they are not pathogens.

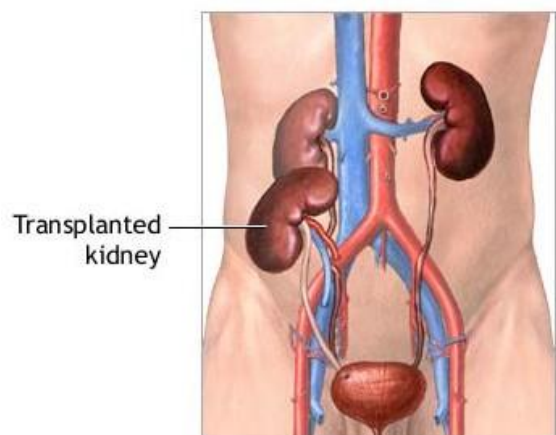
If a person's **kidneys** fail, they can be given a new kidney taken from another person. However the recipient's immune system will recognise the cells in the new kidney as '**foreign**', and will attack and destroy them.

The transplanted organ triggers an immune response, **antibodies** are secreted and the organ may be rejected. This is called **tissue rejection**.



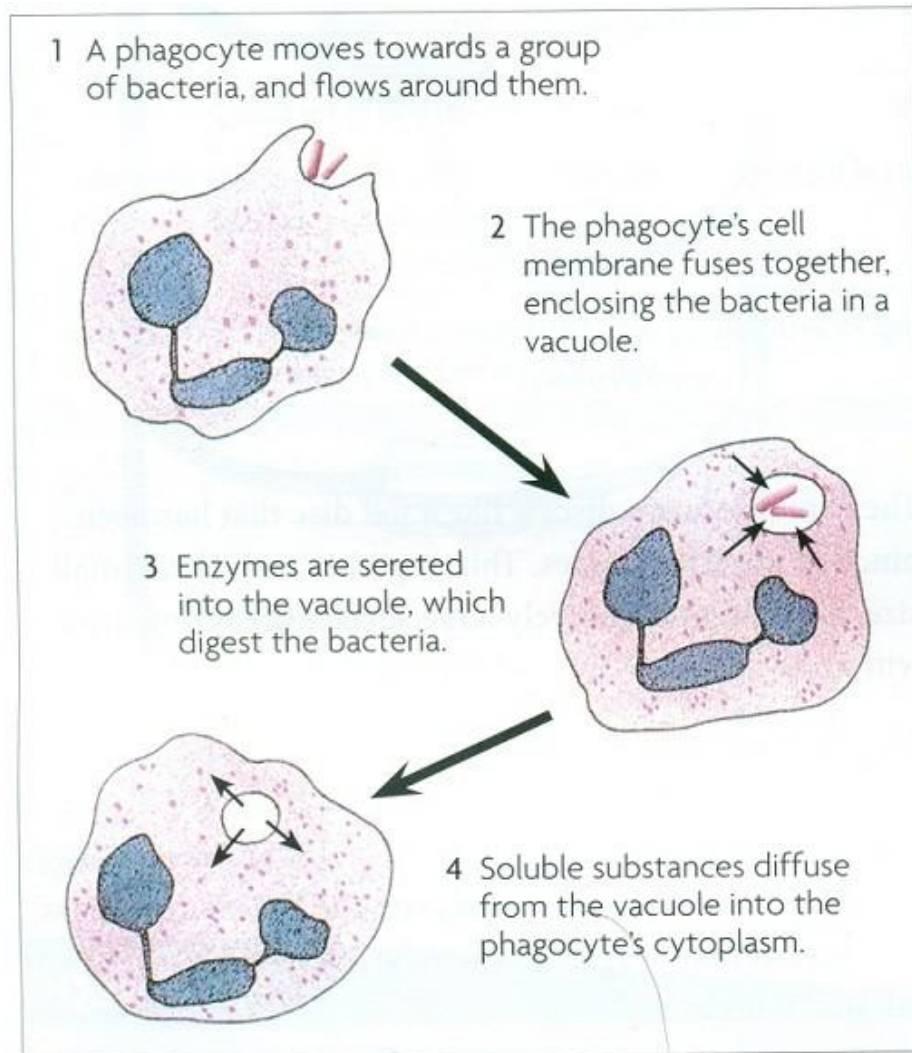
To prevent this happening:

- The donor organ needs to be a **similar** tissue type to that of the patient e.g. from a close **relative**.
- **Immunosuppressive** drugs are used, which switch off the body's immune response. While recovering, transplant patients are at risk of dying from any disease they are exposed to, so they need to be kept in **isolation**.



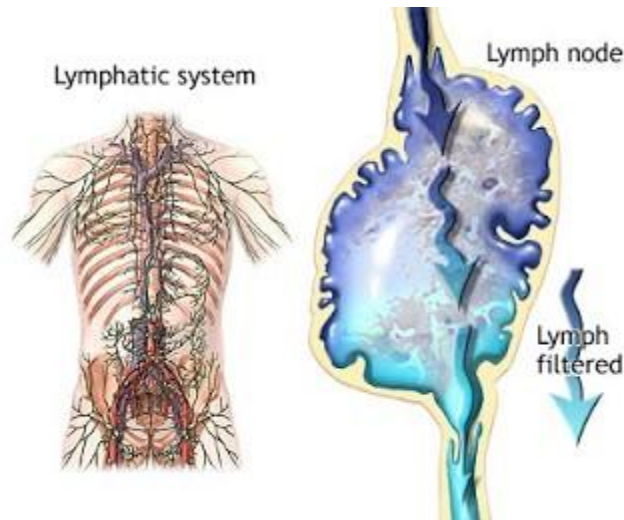
Phagocytosis

Phagocytes have the ability to move out of capillaries to the site of an infection. They then engulf (ingest) the infecting pathogens and kill them by digesting them.



Video: Phagocytosis of a Paramecium (unicellular ciliate protozoa)

#77 Functions of lymphatic system

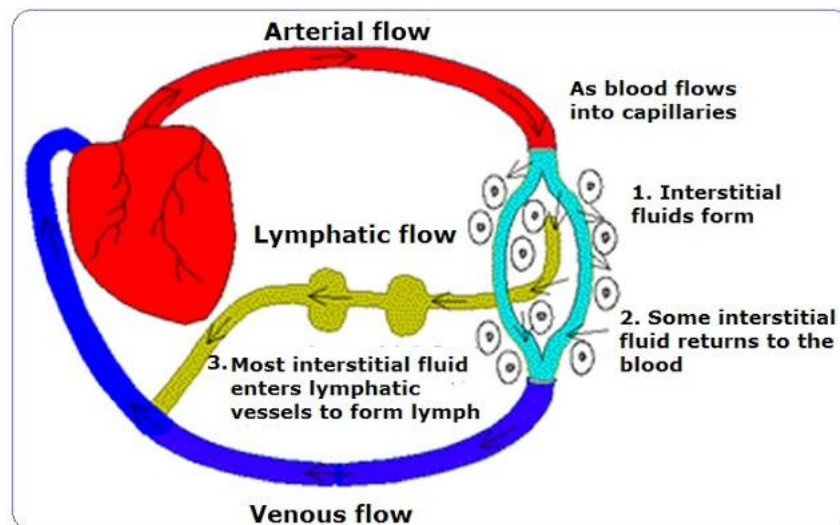


The **lymphatic system** is a collection of lymph **vessels** and **glands**. It has 3 main roles:

- **Fluid balance**: return **tissue fluid** to the blood
- **Protection from infection**: produce white blood cells **lymphocytes**
- **Absorption of fats**: transport digested **fats** from **villi** to blood stream

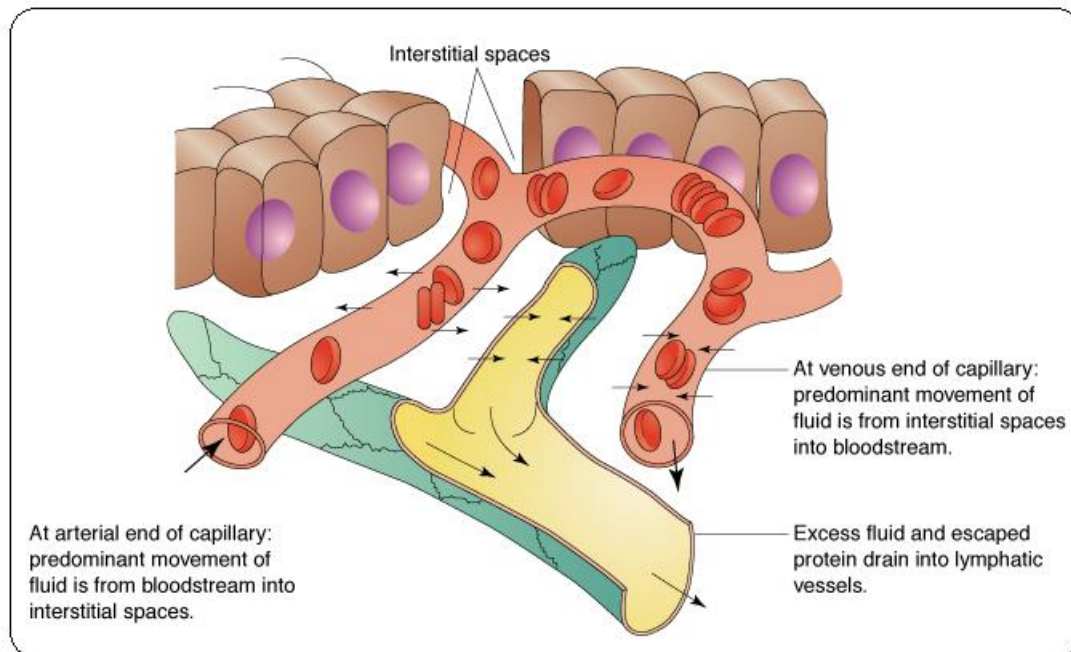
1. Lymph and Tissue Fluid

Tissue fluid is a fluid surrounding the cells of a tissue. It is **leaked plasma** - Plasma from the blood capillaries move to the tissue through gaps in the walls and become tissue fluid.



Tissue fluid play an important role in **substance exchange** between blood and cells. It supplies cells with **O₂** and **nutrients** and takes away **waste** products including **CO₂**.

At the end of the capillary bed, the tissue fluid leaks back into the blood, and becomes plasma again, but not all of it. A little of it is absorbed by the lymphatic vessel and becomes **lymph**.



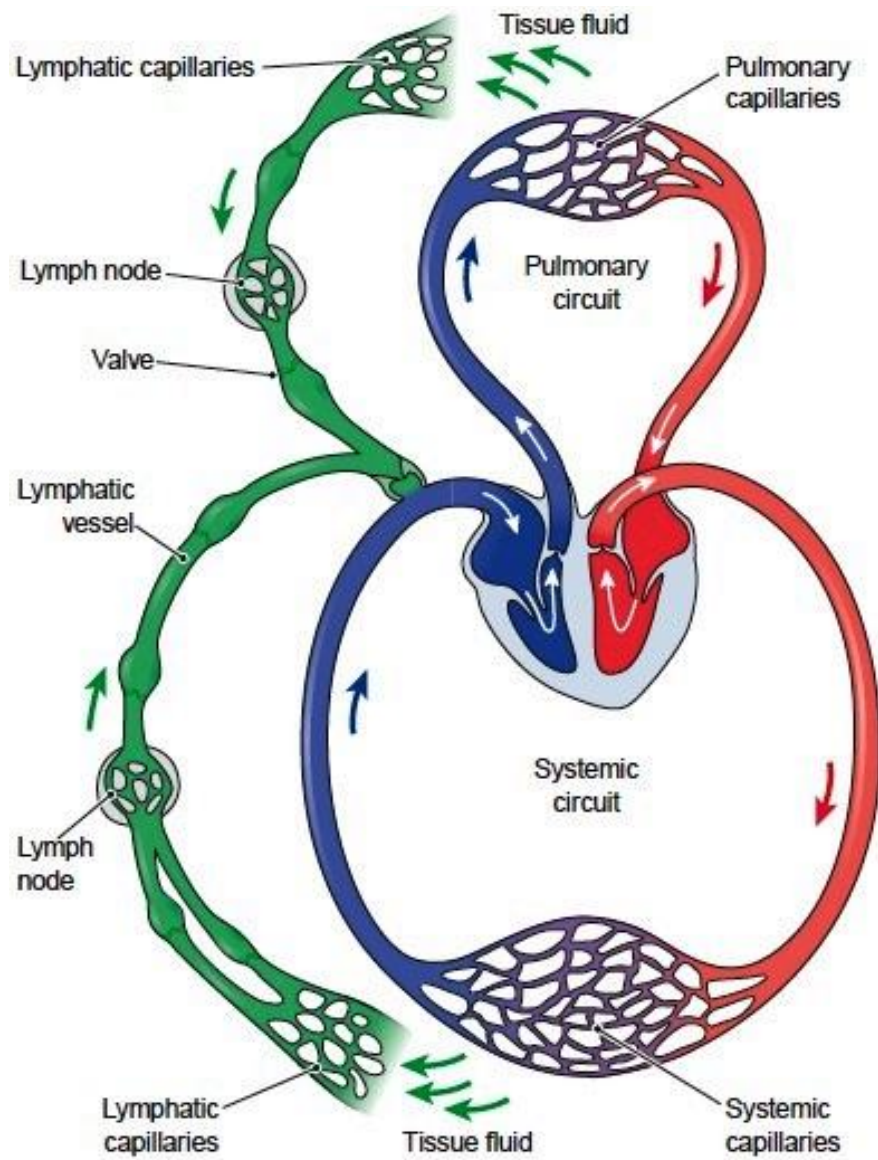
The lymphatic vessel takes the lymph to the blood stream by secreting them in a vein near the heart, called **subclavian vein**. The lymph in the lymphatic vessels are moved along by the squeeze of muscles against the vessel, just like some veins.

The return of tissue fluid to the blood in the form of lymph fluid prevents fluid built up in the tissue.

2. Production of lymphocytes

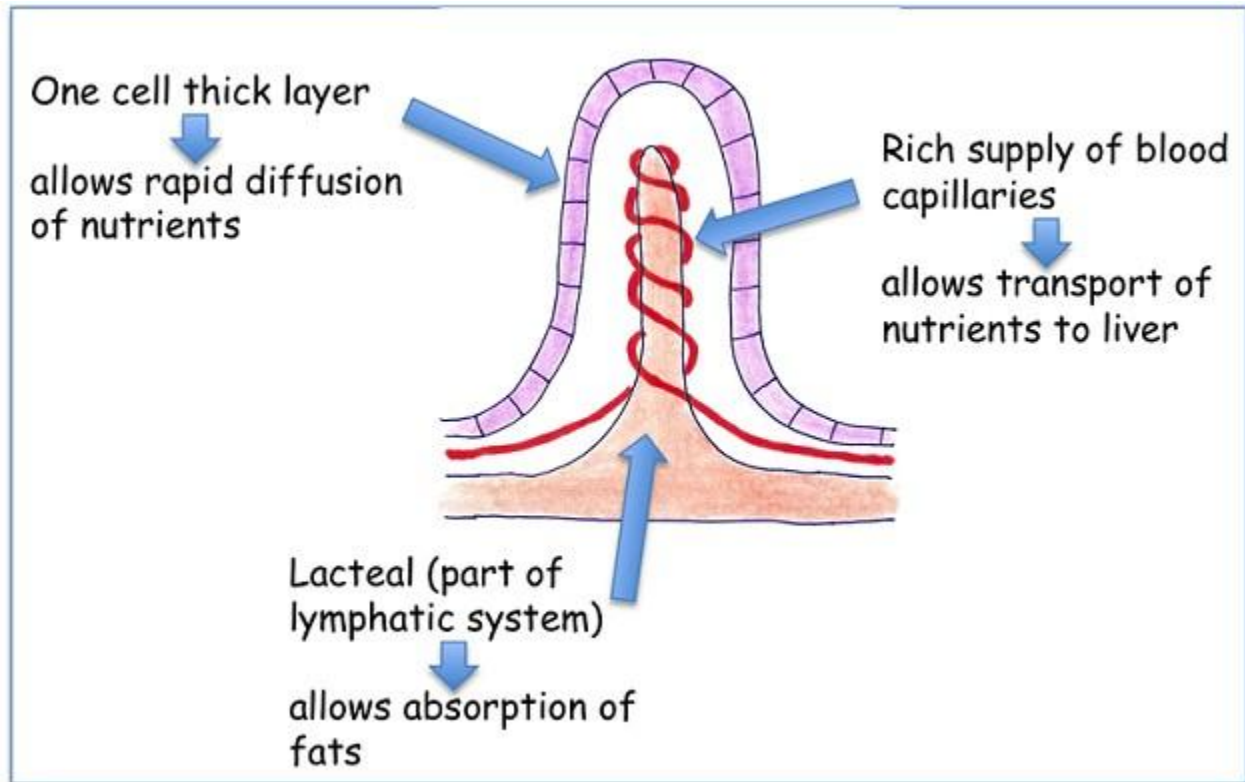
The lymphatic system is an important component of the **immune system**, which fights infection. One group of white blood cells, the lymphocytes, are made in **lymph glands** such as the **tonsils**, **adenoids** and **spleen**. The glands become more active during an infection because they are producing and releasing large numbers of lymphocytes.

The lymphocytes can live and **multiply** in the lymphatic system, where they attack and destroy **foreign organisms**. Lymphoid tissue scattered throughout the body filters out pathogens, other foreign matter and cellular debris in body fluids.



3. The absorption of fatty acids and glycerol from the small intestine

Following the chemical and mechanical breakdown of food in the digestive tract, most nutrients are absorbed into the blood through **intestinal capillaries**. Many digested **fats**, however, are **too large** to enter the blood capillaries and are instead absorbed into **lymphatic capillaries** by **intestinal lacteals**. Fats are added to the blood when lymph joins the bloodstream.



Each [villus](#) contains a lacteal - a blind ending lymph vessel.

Additional source: [lubopitko-bq Xtremepapers](#)

Related topic: [Absorption – function of the small intestine and significance of villi](#)

Video: Lymphatic system

<https://www.youtube.com/watch?v=Kh-XdNnTZUo>

#78 Summary of human transport

- Mammals have a double circulatory system, in which blood is moved through vessels by the regular contraction and relaxation of cardiac muscles in the wall of the heart.
- Blood enters the atria of the heart, flows through open valves into the ventricles, and is then forced out into the arteries during systole.
- The ventricles have thicker walls than the atria, and the left ventricle has a thicker wall than the right ventricle, to allow them to produce a greater force when the muscles contract, necessary so that they can push the blood further.
- In coronary heart disease, the coronary arteries become blocked, so oxygen is not delivered to the heart muscles and they stop contracting. Smoking, stress and a diet high in saturated fats increase the risk.
- Arteries are thick-walled, elastic vessels that carry pulsing, high-pressure blood away from the heart. They split into capillaries, which are tiny vessels with walls only one cell thick. Capillaries take blood close to every cell in the body, so that the cells are supplied with oxygen and nutrients and have their waste products removed. Capillaries join up to form veins. Veins are thin-walled vessels with valves, which carry low-pressure blood back to the heart.
- Blood contains red cells, white cells and platelets floating in plasma. Plasma transports many different substances in solution. Red cells contain the iron-containing protein haemoglobin, which transports oxygen. White cells fight against bacteria and viruses. Platelets help the blood to clot.
- Fluid leaks out of capillaries to fill the spaces between all the body cells, where it is called tissue fluid. It is collected into lymph vessels which carry it back to the bloodstream.

