Transport in Man (chapter 6)

Purpose: to transport substances from one organ to another in an efficient manner.

Paramechia unicellular contractile Vacuoles:
Collecting substances to transport to other parts of the cell.
If it is a waste substance, it will be removed from the cell.
Diffusion helps to move substances in and out of the cell through the cel membrane, which works out because the cell is in constant contact with everything.

However, this does not work for multicellular organisms. too many layers of cells that are not in contact with surroundings, hence nutrients and water cannot diffuse into the body like unicellular organisms.
It would also be difficult to remove waste products in time just by simple diffusion, Hence, a transport system is present to carry substances from one part of the body to another.

Blood:
Red Blood Cell:
Function: To transport oxygen from the lungs to other parts of the body.
Adaptations:

a. circular biconcave shape
    i. increased surface area to volume ratio to increase the efficiency of absorption
b. no nucleus
    i. so that it can carry more haemoglobin
c. contain red pigment called haemoglobin
    i. haemoglobin is a substance that can reversibly combine with oxygen
d. are flexible

The RBC's haemoglobin binds with oxygen in the lungs (where oxygen concentration is high) to form oxyhaemoglobin. In tissues where oxygen concentration is low, oxyhaemoglobin releases the contained oxygen to the tissue cells.

Transporting is not the same as needing.
Eg: RBC does not use oxygen when transporting it.

Plasma:
A yellowish liquid found in blood. It contains mostly water (a good solvent, which allows for most of the substances to be dissolved). and substances like glucose, salts, proteins, amino acids, fats, vitamins, hormones and excretory products like urea. It also contains red and white blood cells.

Function: to transport:

a. blood cells around the body
b. nutrients from the small intestines to other parts of the body
c. excretory products from organs where they are produced to excretory organs for removal
d. hormones from endocrine glands to target organs.

It also contains antibodies.

White Blood Cell:

Two types:

a. Phagocytes
    i. Function: perform phagocytosis
        1. Phagocytosis is a process in which a WBC engulfs and destroys foreign particles like bacteria
    ii. Adaptation:
        1. Can move on its own
b. Lymphocytes
    i. Function: produce antibodies (protein based) that
        1. recognise foreign particles
        2. **engulf and destroy** disease-causing organisms (pathogens) like bacteria and viruses
        3. cause bacteria to clump together for each **engulfing**/ingestion by phagocytes
        4. neutralise toxins produced by bacteria

They are irregular in shape and each have a nucleus

Platelets:

Function: to be involved in blood clotting

Platelets are fragments of cytoplasm that contain:

a. Thrombin (an enzyme) that catalyses the conversion of fibrinogen to form sticky fibrin threads (they are only sticky with exposure to outside air) which:
    i. form a network that entangles RBCs to form a clot which:
        1. prevents excessive blood loss
        2. prevents the entry of harmful organisms (pathogens) into the bloodstream

<u>Blood Clotting:</u>

Blood exposed to air will quickly coagulate (it is also like denaturing but please don't say denaturing, becomes sticky and solidifies to form clots)/clot. This clot seals the wound and

performs aforementioned functions. Fibrinogen breaks down with the help of Thrombin (an enzyme) into the long fibrin thread.

Collagen is exposed when the skin is broken, which attracts platelets to seal the wound. A scab is essentially the platelets and blood cells that are used as the blood clot. It covers the wound as the skin heals and falls off once the skin is completely healed.

For people with the hereditary disease called haemophilia, their ability to blood clot is severely impaired. Slight injuries, if not immediately treated, may cause them to bleed out or die from internal bleeding.

Mechanism:

a. Platelets are involved in converting fibrinogen to fibrin, this process involves thrombin, an enzyme.
b. Fibrin threads entangle blood cells and the whole mass forms a clot or a scab. This seals the wound.

Other information:
The ratio of red blood cells to white blood cells it about 1:100

Tissue Rejection:
In an organ transplant, an organ/tissue when failing would be replaced with another person's organ. However, when the **white blood cells** recognise it as a foreign body (any organ from another person may be treated as a foreign body), these white blood cells would work to produce antibodies to destroy the foreign organ/tissue. This is tissue rejection.

Methods to reduce chances of tissue rejection:

a. find a genetically similar person
b. use **immunosuppressant drugs** to inhibit the responses of recipient's immune system

Blood Transfusion:

Blood Type	Gives	Receives
A+	A+, AB+	A+, A-, O+, O-
O+	O+, A+, B+, AB+	O+, O-
B+	B+, AB+	B+, B-, O+, O-
AB+	AB+	Everyone
A-	A+, A-, AB+, AB-	A-, O-
O-	Everyone	O-
B-	B+, B-, AB+, AB-	B-, O-
AB-	AB+, AB-	AB-, A-, B-, O-

Other blood types (not in syllabus):
Rh-null blood (Golden Blood) - it has no antigens at all and is extremely rare, with only >50 cases identified worldwide. It is literally the universal donor, but they can only take from another Rh-null donor.

When a person loses too much blood, a doctor will transfer blood from one person to this person.

Genetics defines blood types (A, B, AB, O (the only recessive one)
The positive or negative is from the genetics too (rhesus factor aka Rh factor) This stems from the antigen called Rh. If present, the blood type is positive and vice versa. There are more than 50 different Rh antigens too.

When two different blood types mix (specifically contrasting ones): the blood will agglutinate (v: agglutinating) and cause clumps in the blood that block blood vessels, which cause death.

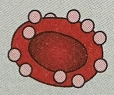
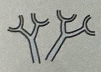
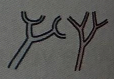
Outside the blood cell membrane, there are antigens (either A and/or B depends on blood type) on it. This allows for the immune system to identify cells and determine whether they are foreign or not. O does not have any antigens on the outside of the blood cell membrane.

Antigens and Antibodies:

ANtibodies bind to specific antigens
Blood Type A has antigen A and the plasma has antibody b.
Blood Type B has antigen B and plasma has antibody a.
Blood Type O has no antigens and the plasma has antibodies a and b.
Blood type AB has both antigens A and B and the plasma has no antibodies.

There are four blood groups, named A, B, AB and O. Table 6.1 shows you the antigens and antibodies present in the different blood groups.

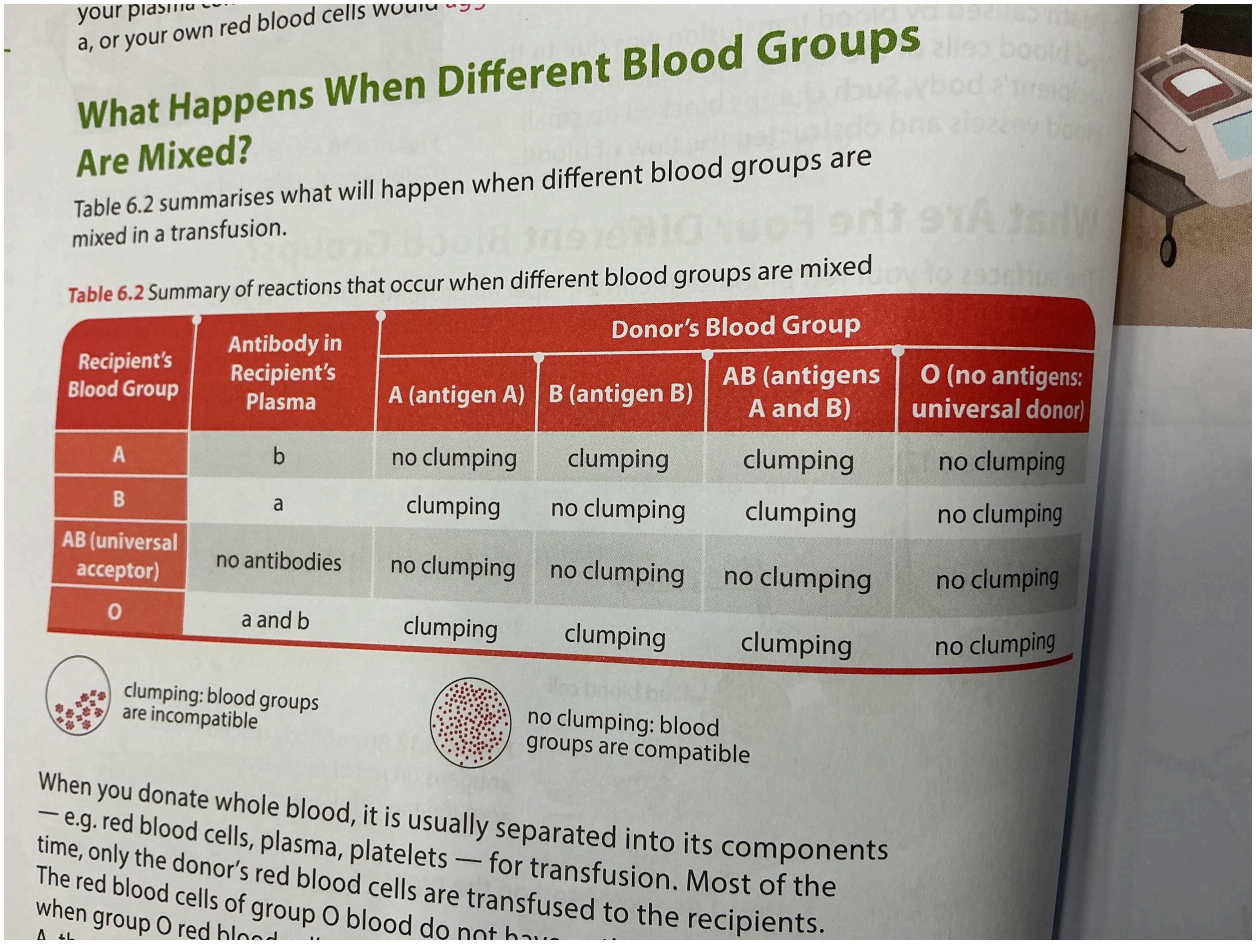
Table 6.1 Types of antigens and antibodies in different blood groups

Blood Group	A	B	AB	O
Red Blood Cell				
Antigen on Red Blood Cell	antigen A 	antigen B 	antigens A and B 	no antigens
Antibody in Plasma	antibody b 	antibody a 	no antibodies	antibodies a and b 

If you belong to blood group A, your red blood cells possess antigen A and your plasma contains antibody b. Your plasma could not contain antibody a, or your own red blood cells would agglutinate.

What Happens When Different Blood Groups Are Mixed?

Table 6.2 sum



a, or your own red blood cells would

What Happens When Different Blood Groups Are Mixed?

Table 6.2 summarises what will happen when different blood groups are mixed in a transfusion.

Table 6.2 Summary of reactions that occur when different blood groups are mixed

Recipient's Blood Group	Antibody in Recipient's Plasma	Donor's Blood Group			
		A (antigen A)	B (antigen B)	AB (antigens A and B)	O (no antigens: universal donor)
A	b	no clumping	clumping	clumping	no clumping
B	a	clumping	no clumping	clumping	no clumping
AB (universal acceptor)	no antibodies	no clumping	no clumping	no clumping	no clumping
O	a and b	clumping	clumping	clumping	no clumping

clumping: blood groups are incompatible

no clumping: blood groups are compatible

When you donate whole blood, it is usually separated into its components — e.g. red blood cells, plasma, platelets — for transfusion. Most of the time, only the donor's red blood cells are transfused to the recipients. The red blood cells of group O blood do not have

when group O red blood

The antibodies in this blood DO NOT FIGHT BACTERIA.

Typically, antibodies are represented by lowercase letters.

When blood is donated, it is usually separated into components (red blood cell, plasma, platelets) for transfusion. Most of the time, only the red blood cells are donated. This basically means that only the antigens are what matters in blood donation.

Basically, antigen A cannot go with antibody A and the same goes for vice versa

The Circuitory System:
Double circulation, each cell goes through the heart twice in order to complete ONE circuit.

Two circuits: Pulmonary Circuit (Lungs and Heart), Systematic Circuit (Heart and Body)

Systematic Circuit:

- exchanges general substances like waste products and nutrients

Pulmonary Circuit:

- Go specifically, only to the lungs, for an exchange of gases (Carbon Dioxide released and binding of oxygen)
- Oxygenated blood then returns to the heart, and then goes back into the systematic circuit

Blood Vessels:

Artery - transports blood away from the heart
Vein - transports blood towards the heart
Capillary - allows for exchange of substances such as:

a. nutrients
b. waste substances (urea)
c. gases

between the blood and cells of the organ.
Function of the blood vessels

Artery:
Functions: Carries blood away from the heart
Adaptations:

1. Thick elastic walls to maintain the high blood pressure of fast flowing blood in the artery

The blood coming from the heart is at a very high blood pressure, as it is right next to the pump (heart). Since the blood pressure is so high, the walls of the arteries are extremely thick and elastic. They are receiving blood directly from the heart and need to be able to withstand that pressure. This prevents the artery itself from rupturing/tearing, and its walls are to be described as **thick, muscular and elastic**. The space where the blood flows through the artery is the lumen. This applies to almost all bio stuff. Any tube that allows for liquid to pass through is called a lumen in biology.

Maintaining pressure — because walls are muscular. This means that the walls are able to contract and relax, being able to adjust to the high blood pressure.

extra Maintaining pressure — it can snap back to its original state after being stretched and hence exerts force in going back.

Elastic — it can be stretched **and** return to its normal shape. Pressure is force/area
Inner walls provide area, force is by the blood. The elastic enables the wall to stretch and recoil to push the blood in spurts and maintain high pressure. This ensures the maintenance of a small lumen (Pressure = F/A). This helps to transport blood. further distance to reach all organs.

The artery has a smaller lumen compared to the vein, and the blood that it is receiving is at a higher pressure. The pressure must be high to ensure that the blood can flow a far distance and is still able to come back. When the heart pumps, blood flows. When the blood passes through, it

should contract once again and the lumen should should return to its original size in order to maintain the blood pressure.

When talking about muscles - use contract and relax.

a. contract - narrow the lumen and less blood flows through
b. relax - lumen dilates and lumen becomes wider, allowing more blood to flow through.

Vein:
Functions: Carries blood towards/into the heart
Adaptations:

1. Much thinner, less muscular and less elastic walls
2. ***Semi-lunar Valves*** to prevent deoxygenated blood from flowing backwards.
3. Vein has a wider lumen compared to artery

In the veins, blood flows at a lower pressure and is not as fast with as much force as blood in the artery. Thick muscular walls are needed to withstand the pressure. The presence of internal valves is to prevent the backflow of blood due to low pressure and being against gravity.

In the lumen of the veins, it is much larger as it does not have a higher internal pressure to withstand unlike the artery. In exams, we have to identify a vein vs an artery.

When you sit for too long and get pins and needles, then move, you engage your skeletal muscles. The skeletal muscles push against the walls of the veins, entering pressure on the veins, which contracts the lumen and pushes the blood forward.

Capillary:
Functions: Allows for exchange of substances between blood and other cells via diffusion.
Movement of substances is mostly by diffusion, with the exception of water (osmosis)
Adaptations:

1. Wall of the capillary is one cell thick to allow for easy exchange. This allows for a shorter diffusion distance (allows cells to diffuse more quickly)

Substances that move from blood into cells:

a. oxygen (from red blood cells)
b. dissolves food substances (from plasma)
c. waste products (from body cells to plasma)
    i. e.g: CO_2 and urea

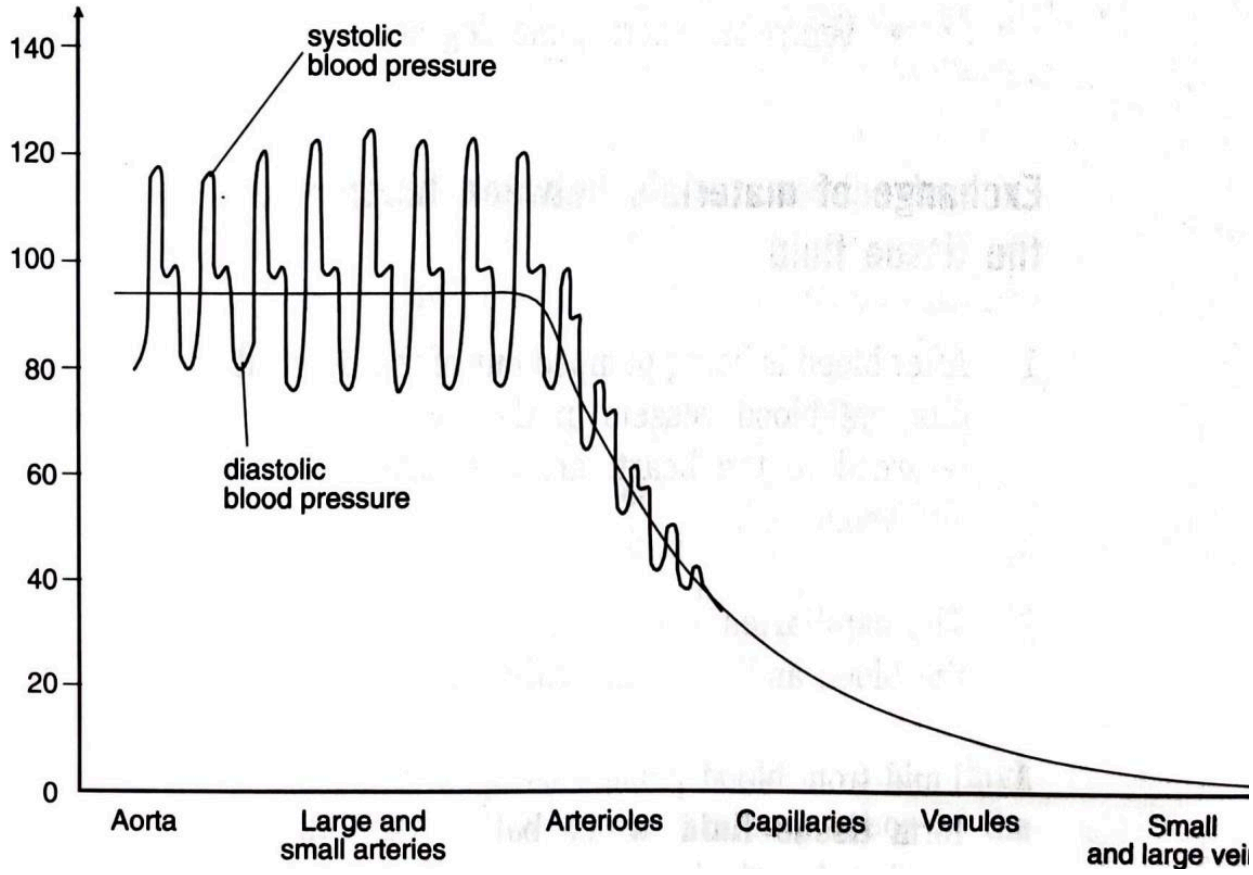
Because the tissue cells are always carrying out respiration, it will always be using up the oxygen and giving out CO_2. This leads to a concentration gradient where oxygen can diffuse in and CO_2 can diffuse out.

Capillary does not make direct contact with tissue cells. The space between capillaries and the body cells is known as tissue fluid, which is defined as a yellow fluid that surrounds cells. It contains the same substances as blood plasma except for plasma proteins. **It is also a space that allows for exchange of dissolved substances between the blood and the body cells.**

Tissue fluid should just about be the same as blood plasma and its components come from blood plasma.

Why no plasma protein? The plasma proteins (fibrinogen, antibodies) cannot pass through the cell membrane of the capillary walls as they are large molecules unlike amino acids. The white blood cells can pass through the capillary walls as it is irregular in shape and mobile.

(c) The fluctuations in blood pressure diminish in the arterioles and do not occur in the capillaries, venules and veins.



The upward spike comes from the contraction of the left ventricle during diastole. During Diastole, the heart is not exerting pressure on blood in the arteries but some pressure is still maintained in the arteries due to elastic recoil (the snap back). The fluctuations are generally just the heart pumping.

Pressure decreases later because the blood gets further and further away (like a river breaking up into streams).

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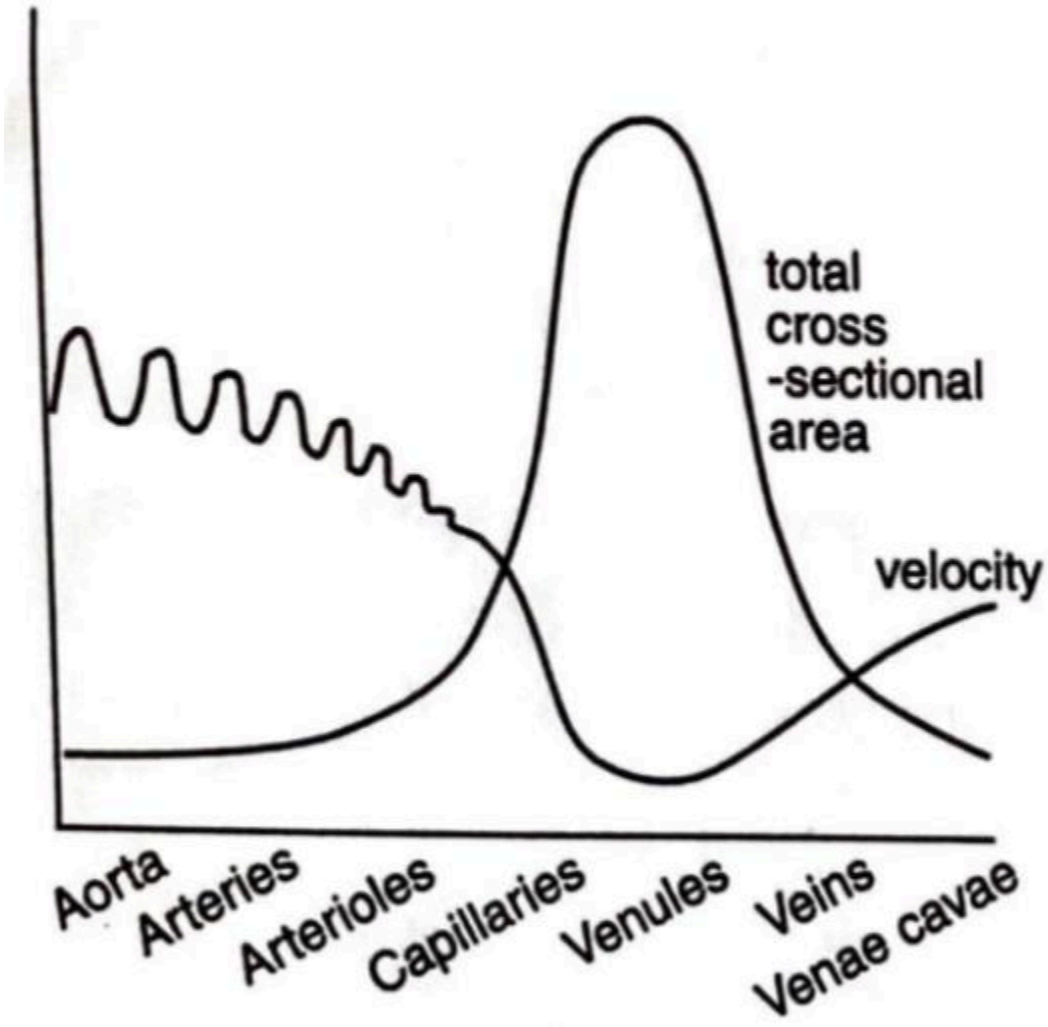
Graph of velocity of blood travelling through the blood vessels
Capillaries have most area bc its exchanging substances with all the cells



Drop in velocity in the capillaries is so that blood has more time to carry out exchange of substances.

The blood in veins suddenly increases in velocity — why?
When your body moves, the muscles near the walls of the veins contract and exert pressure onto the veins (this does not increase pressure in the vessel itself) and forces blood to move forward within it. The valves within the veins prevent backflow of the blood.

Heart:
Inside the heart, there are chambers where blood flows through. It is mostly made up of muscle cells (which contract and relax in movement, helping to pump blood) which form **cardiac muscles** (name of the tissue) which contract to generate a ***high pressure*** in order to ***force*** blood out of the heart to the rest of the body.

Names of the parts of a heart:

- pulmonary artery (artery that goes to the lungs)
    - there's two of them because there are two lungs
    - it carries deoxygenated blood away from the heart
- pulmonary veins
    - this carries the oxygenated blood into the heart. It passes through the left atrium, then the left ventricle, and then through the aorta.
- aorta (largest artery in the body, splits into smaller arteries that goes to the organs)
    - carries oxygenated blood away from the heart to the rest of the body
- vena cava (largest vein in the body)
    - it carries deoxygenated blood coming from all parts of the body
- coronary arteries
    - the blood vessels responsible for delivering nutrients and O2 to the heart muscle cells. They branch out from the aorta and extend to all regions of the heart.
- right atrium (upper right side)
    - when it contracts, it forces blood to flow into the right ventricle. Also, the right ventricle is relaxed throughout this process.
- left atrium (upper left side)
    - both atriums always receive blood. Their walls are very thin as they only need to receive blood and the blood flows downwards.
- right ventricle (lower right side)
    - the right ventricle has much thinner walls compared to the left ventricle as it only pumps blood to the lungs, which is close to the heart.
    - When it contacts, it closes the tricuspid valve and creates the first heartbeat with a loud noise.
- left ventricle (lower left side)

    - It has very thick walls that produce extra force to pump blood further.
    - When it contracts, it closes the bicuspid valve and creates the second heartbeat
- tricuspid valves (two) (right side)
- bicuspid valves (two) (left side)
- semi-lunar valves (two, one on each side of the heart)
    - the three sets of valves only open one way to prevent backflow from x location to y location.
        a. tricuspid valves prevent backflow of blood from right ventricle to right atrium,
        b. bicuspid valves prevent backflow of blood from left ventricle to the left atrium,
        c. aortic valve (semi lunar valve in aorta) prevents backflow of blood from aorta to left ventricle,
        d. pulmonary valve (semi lunar valve in pulmonary artery) prevents backflow of blood from pulmonary artery to the right ventricle.
- chordae tendineae
- heart muscle
- median septum (dividing wall)
    a. The tissue that divides the heart into two. It's purpose is to prevent the mixing of oxygenated and deoxygenated blood, which is to maintain a greater/steeper concentration gradient for diffusion in exchanges of substances.

The two sides of the heart are separated. One is for oxygenated, the other is for deoxygenated blood.

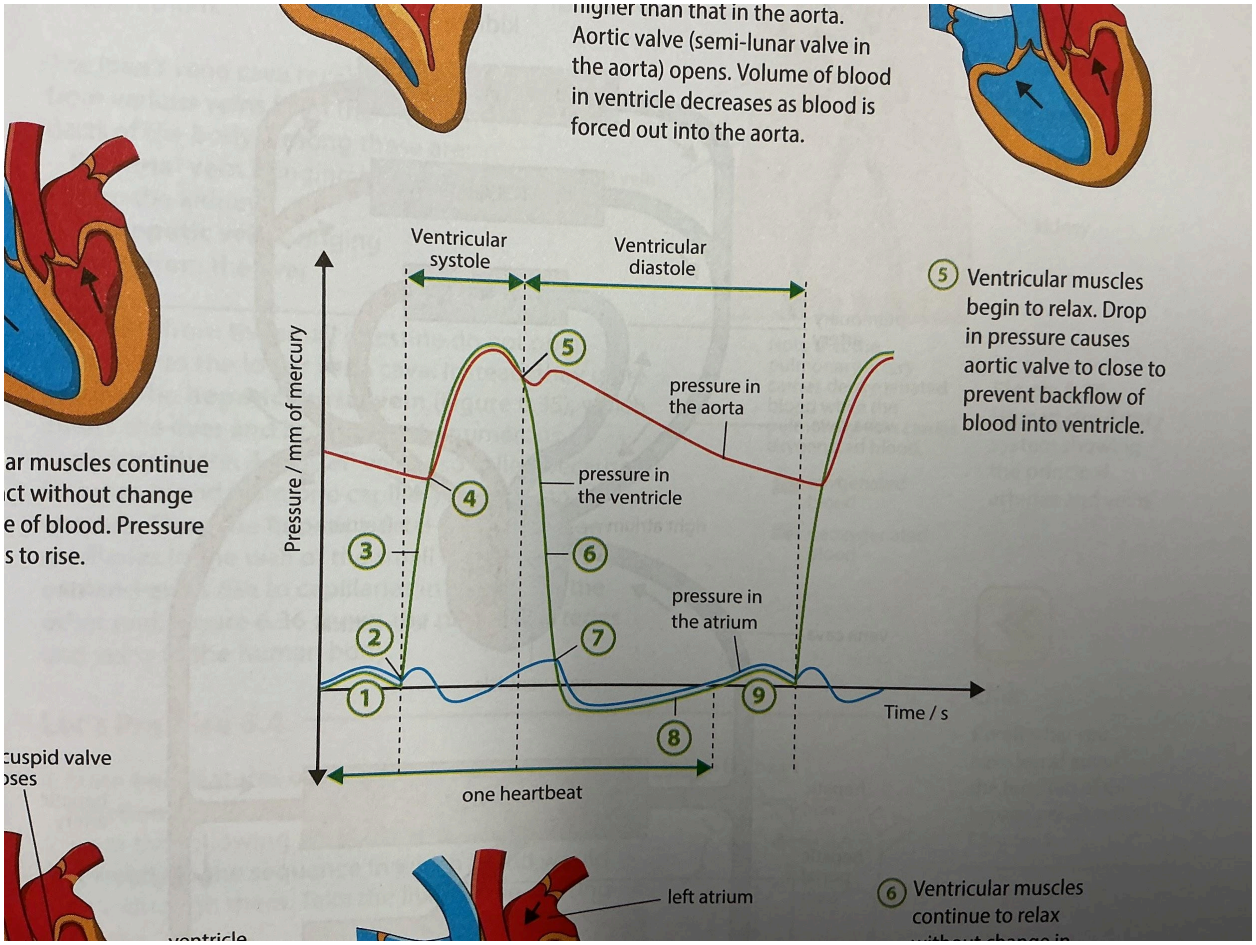
The chambers of the heart make the heart have a double pump. Deoxygenated blood enters the heart to the right atrium, and then flows down to the right ventricle.

Gas and substance exchange relies on diffusion for movement. Diffusion requires a concentration gradient for it to function, the steeper the faster. So when deoxygenated blood is transported to the lungs to take oxygen, the steep concentration gradient allows for faster diffusion and more blood haemoglobin binding to oxygen.

If you look at the walls of the left ventricle of the heart, it is very thick. This is for so that when it contracts, it produces a large force to pump blood out of the organs (greater distance). This allows blood to travel further.

<u>*NOTE THAT ALL DIAGRAMS OF THE HEART ARE GIVEN IN A MIRROR IMAGE. LEFT IS RIGHT AND RIGHT IS LEFT.</u>

Pressure changes in the Heart



Key: Red -> pressure in the aorta
Blue -> pressure in the atrium
Green -> pressure in the ventricle

1: A slight increase in the ventricular pressure is due to the contraction of the left atrial muscles. forcing blood into the ventricle.
2: Ventricular muscles begin to contract. Bicuspid valve closes.
3: Ventricular muscles continue to contract without change in volume of blood. Pressure continues to rise.
4: Pressure in ventricle becomes higher than that in aorta. Aortic valve (the semi lunar valve in the aorta) opens. Volume of blood in the ventricle decreases as blood is forced out of the ventricle and into the aorta.
5: Ventricular muscles begin to relax. The drop in pressure causes the aortic valve to close to prevent backflow of blood into the ventricle.
6: Ventricular muscles continue to relax without change in the volume of blood.
7: Bicuspid valve opens when the pressure in the ventricle becomes lower than that in the atrium.

8: Pressure in the ventricle rises as blood continues to enter the ventricle from the atrium.
9: Atrial walls contract and squeeze blood into ventricles.

Essentially, valves open when the pressure is high in the atrium, and close when pressure is low in the atrium.

Refer to Google Classroom for a more detailed graph. If you need this explained again, check the recording Ms Deepa sent (no its not her voice D:)

Consider what is causing the pressure to change?

a. Muscles in the walls of the atria/ventricles. E.g: muscle contracts, pressure increases and the converse is true.
b. When blood enters or leaves the chambers. Blood has more molecules compared to vacuum and pressure = F/A. When blood leaves, the chambers, pressure decreases.
    i. The pressure differences between spaces causes the valves to open/close.
    ii. If the pressure in the atria is higher than the pressure in the ventricles, the valves open. When the pressure in the ventricles is higher than the pressure in the atria, the valves close.
    iii. This will be presented as "when do the bicuspid/tricuspid valves open?"

Systole: when the walls contract. Usage: Atrial systole (atrium contracts) and Ventricular systole (Ventricle contracts)

Diastole: when the walls relax. Usage: Atrial Diastole (atrium relaxes) and Ventricular diastole (ventricles relax)

So when atrial systole occurs, ventricular diastole occurs and vice versa.

PLEASE PLEASE PLEASE PLEASE CHECK THE GOOGLE CLASSROOM PERIODICALLY SO THAT YOU UNDERSTAND THE GRAPH

Coronary Heart Disease

Definition: a condition where the blood supply to a person's heart muscles is blocked or interrupted by a build up of substances such as fats in the lumen of the coronary arteries. It is named as such as it affects the coronary arteries.

The coronary arteries branch off the aorta to reach the heart muscle cells.

Blockages can occur anywhere. For example, if a blood vessel that supplies blood to the brain is blocked, a stroke may occur. This is not Coronary Heart Disease though.

Symptoms:

- Numbness in the arms
- Chest pains

Sequences of events:

1. Fatty substances (plaque) get deposited on the **inner** walls of the coronary arteries. This is called atherosclerosis (no need to use in answer tho). As a result, the lumen of the coronary arteries are narrowed and blood pressure increases.
2. The affected area develops a rougher inner surface and increases the risk of a blood clot being formed in the artery. If it occurs in the coronary arteries, the supply of oxygen and nutrients/blood can be completely cut off.
3. Since Oxygen and Glucose is needed for respiration in the heart, the muscles of the cells would die as they are unable to respire and would not be able to release energy.
4. The heart may stop beating as a result, and a heart attack occurs.

Risk factors:

a. Smoking
    i. Cigarette smoke contains Carbon Monoxide (CO) and nicotine (which increases blood pressure and the risk of blood clotting in the arteries). The risk of smokers developing coronary heart disease is much higher than non-smokers.
    ii. Carbon Monoxide binds itself to haemoglobin much more easily and this is irreversible. It basically displaces oxygen in Red Blood Cells.
b. Unhealthy diet
    i. A diet high in cholesterol, saturated fats and salt content increases the risk of high blood pressure and a heart attack.
c. Genetic factors
    i. Family history has a role in the risk of developing heart disease. High blood pressure and high blood cholesterol can run in the family.
d. Age
    i. The risk of a heart attack increases with age. Most people who suffer from coronary heart disease are 65 years and older.
e. Sedentary lifestyle
    i. Lack of exercise and being inactive lead to the build-up of fatty deposits that block the arteries. This increases the risk of getting coronary heart disease.

To reduce the risk of getting coronary heart disease…

a. Have a healthy diet to reduce the risk of atherosclerosis. Animal fats can be substituted with polyunsaturated plant fats, which do not stick to the inner surface of th arteries. This may also lower the cholesterol level in the blood.

b. Smoking should be avoided. Avoiding nicotine and carbon monoxide may reduce the risk of getting coronary heart disease.
c. Exercise regularly, this will strengthen the heart and maintain the elasticity of the arterial walls. The risk of high blood pressure or hypertension can be greatly reduced.