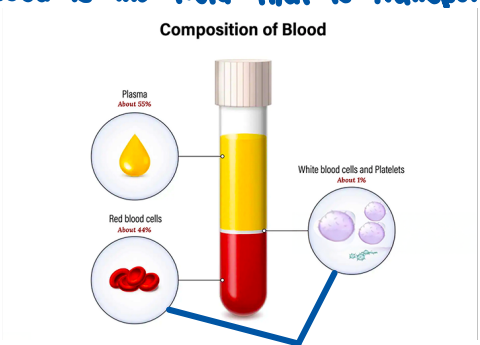
transport in humans

composition of blood:

- blood is the fluid that is transported around the body



cellular elements (45%)

① plasma

- the fluid in which the cellular components of blood are suspended in

components of plasma include:

1. water — a solvent to carry other dissolved substances
2. ions e.g. sodium and potassium — to maintain the water potential of blood
3. plasma proteins
4. soluble nutrients
5. metabolic waste
6. carbon dioxide
7. hormones

② cellular elements

found suspended in the plasma

- cellular elements of blood include:

1. red blood cells
2. white blood cells
3. platelets

feature	adaptation
presence of haemoglobin	allows it to bind reversibly to oxygen, transporting it from lungs to body cells
lack of nucleus	more space to carry more haemoglobin, allowing the cells to carry more oxygen
biconcave shape	increases SA:V ratio, allowing oxygen to diffuse in and out more quickly
elastic	allows it to squeeze into narrow capillaries

red blood cells

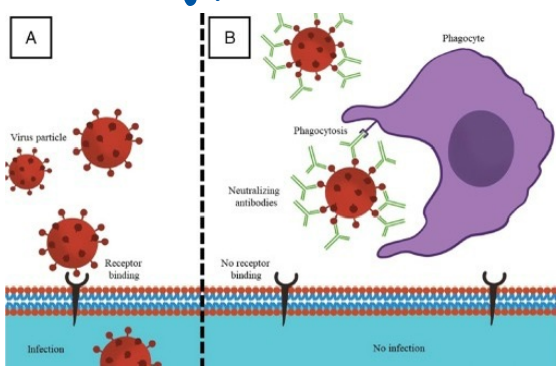
- present in very large numbers
- contain haemoglobin that binds reversibly to oxygen
  - enables rbc to transport oxygen from lungs to body cells

white blood cells

- help defend the body against diseases
- fewer white blood cells than red blood cells
- two main types of white blood cells

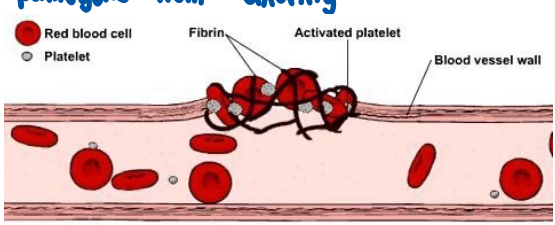
1. lymphocytes which produce antibodies
   - antibodies are proteins
   - antibodies bind to pathogens or their toxins, neutralising them
   - antibodies bind to pathogens, signaling the phagocytes to engulf them
   - the toxin or part of the pathogen that antibodies bind to are called antigens. each antibody is specific and only binds to a certain antigen

surround, engulf, destroy pathogens (phagocytosis)



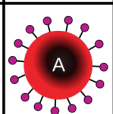
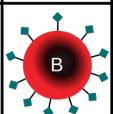
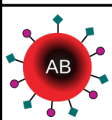
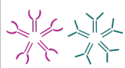
platelets

- fragments of cells and are essential in blood clotting
- when there is a cut, the platelets are attracted to the break. they trigger a series of events that converts the soluble plasma protein, fibrinogen, into an insoluble protein called fibrin
- the fibrin strands form a mesh of fibres, trapping blood cells to form a clot
- this prevents further loss of blood and prevents pathogens from entering



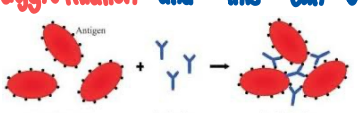
③ blood groups

- four main types of blood groups — group A, B, AB and O
- blood type is determined by the type of antigen that is found on the surface of a person's red blood cell
  1) group A — antigen A
  2) group B — antigen B
  3) group AB — antigen A and B
  4) group O — no antigen
- a person produces antibodies to the antigens that he does not have
  these antibodies are found in the blood plasma

	Group A	Group B	Group AB	Group O
Red blood cell type				
Antibodies in plasma	 Anti-B	 Anti-A	None	 Anti-A and Anti-B
Antigens in red blood cell	 A antigen	 B antigen	 A and B antigens	None

if a person receives a blood transfusion from a different blood type, his antibodies might react to the foreign antigens of the transfused blood

e.g. a person of group A blood receives a transfusion of group B blood, his antibodies b will bind to the B antigens of the transfused blood.
this will cause the red blood cells to clump together in a process known as agglutination and this can be fatal



- since people with AB blood group have no blood group antibodies, they can receive blood from a donor of any blood group. they are known as universal recipients.
- since people with O blood group have no blood group antigens, their blood can be donated to a recipient of any blood group. they are known as universal donors.

④ organ rejection

- patients with a damaged organ may be saved by receiving a healthy organ from a donor
- however, if the donor is not closely related to the patient, the patient's white blood cells may recognise the antigens on the donated organ as 'foreign'
- this triggers an immune response and the white blood cells attack the donated organ, causing it to fail
- this is known as organ rejection
- the more genetically similar the donor and receipient are, the smaller the chances of organ rejection
- however, as no two people are genetically identical, organ receipients usually take drugs to suppress their immune system and lower the risk of organ rejection
- the drugs are called immunosuppressant drugs and the receipient must take them for the rest of their lives
- the side effect of taking these drugs long-term is that the patient becomes more prone to infections by other pathogens

⑤ blood vessels

1) arteries

STRUCTURE

- walls are thick and muscular
  - ↳ to withstand the high blood pressure of blood forced out of the heart
  - ↳ walls are thickest in the arteries nearest the heart
- lumen of artery is narrower than that of veins
  - ↳ contributes to high blood pressure in arteries
- wall of artery is elastic
  - ↳ allows artery wall to stretch and recoil, to withstand the high blood pressure

FUNCTION

- transport blood away from the heart
- most carry oxygenated blood

2) capillaries

STRUCTURE

microscopic blood vessels that are found between the cells of almost all the tissues

- capillary wall is a one-cell thick layer
  - ↳ allows substances to diffuse quickly through the walls, in and out of the capillary
  - the wall is partially permeable
- lumen of capillary is very narrow
- many capillaries branch repeatedly to form an extensive network
  - ↳ increases SA:V ratio for more efficient exchange of substances between blood and the tissue cells
  - ↳ lower blood pressure and slower flow of blood allows more time for exchange of substances between blood and tissue cells

FUNCTION

- exchange of substances between blood and tissue cells

3) veins

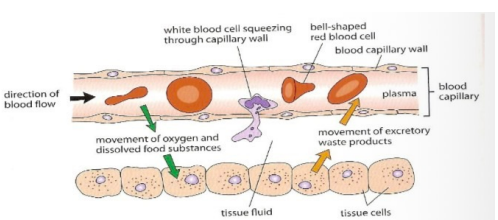
STRUCTURE

- have thinner and less muscular walls, which are less elastic than that of arteries
- have valves to prevent backflow of blood, keeping blood flowing towards the heart
- has a wider lumen than the arteries
  - ↳ pressure is lower

FUNCTION

- transports blood towards the heart
- most carry deoxygenated blood
  - ↳ except for pulmonary vein which carries oxygenated blood from lungs to heart

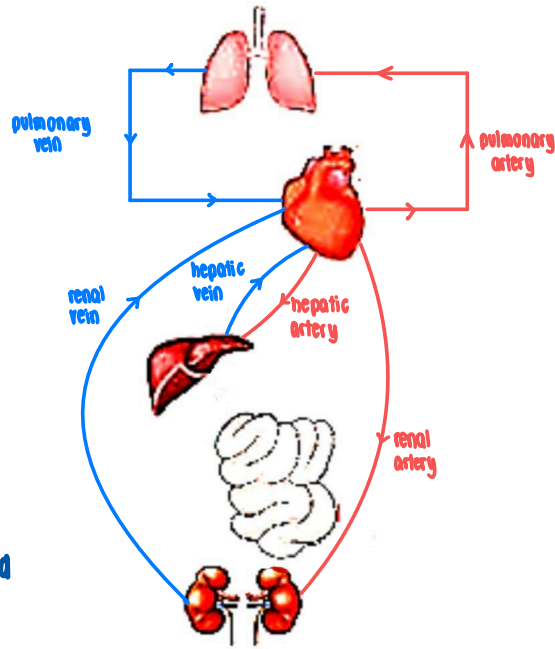
TRANSFER OF MATERIALS BETWEEN CAPILLARIES & TISSUE FLUID



- tissue cells are surrounded by tissue fluid
  - ↓
  - fluid that bathes the cells in most tissues
- how is tissue fluid formed?
  1) blood pressure at arterial end of capillaries is higher than venule end
  2) blood plasma (excluding large molecules like proteins and blood cells) is forced out of capillary walls into spaces surrounding cells as tissue fluid
     - ↳ phagocytes can squeeze out of capillary walls as they change shape
  3) tissue fluid carries substances between tissue cells and blood capillaries
     - ↳ dissolved food substances diffuse from blood in capillaries into tissue fluid and then into cells
     - ↳ waste products diffuse from cells into tissue fluid and then through capillary walls into blood which transports excretory products away for removal

MAJOR BLOOD VESSELS IN THE HUMAN BODY

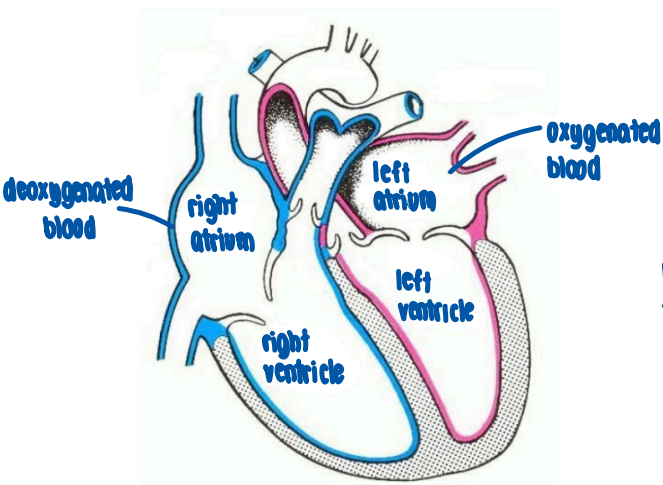
- arteries . transport blood away from heart
- veins: transport blood towards heart
- pulmonary: related to lungs
- renal: related to kidneys
- hepatic: related to liver



THE HEART & CIRCULATION OF BLOOD

structure of the heart

- muscular pump which works via contraction and relaxation



- mammalian heart is divided into 4 chambers
  1) 2 upper chambers called atria (singular: atrium)
  2) 2 lower chambers called ventricles

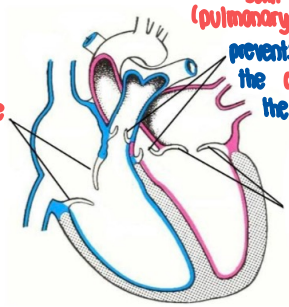
  right and left side of the heart separated by the median septum
  ↳ prevents mixing of oxygenated and deoxygenated blood, which will reduce the amount of oxygenated blood transported to the rest of the body
- deoxygenated blood is transported through the right side of the heart.
  oxygenated blood is transported through the left side of the heart.
  1) right atrium: receives deoxygenated blood from the rest of the body
  2) right ventricle: pumps deoxygenated blood to the lungs
  3) left atrium: receives oxygenated blood from the lungs
  4) left ventricle: pumps oxygenated blood to the rest of the body

MAIN BLOOD VESSELS OF THE HEART

- vena cava transports deoxygenated blood from the rest of the body (other than the lungs) to the right atrium of the heart
- aorta transports oxygenated blood from the left ventricle to the rest of the body (other than the lungs)
- pulmonary artery transports deoxygenated blood from the right ventricle to the lungs
- pulmonary vein transports oxygenated blood from the lungs to the left atrium of the heart

VALVES IN THE HEART

- purpose of valves in the heart:
  valves maintain one-way flow of blood, preventing the backflow of blood

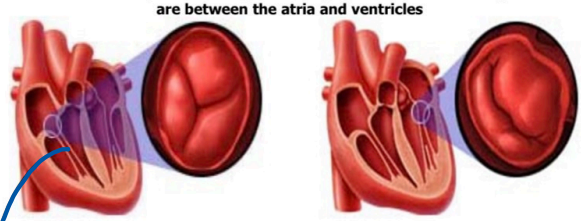


semi-lunar valve
(pulmonary valve/aortic valve)
prevents the backflow of blood from the aorta and pulmonary artery to the left and right ventricle

tricuspid valve
prevents backflow of blood from the right ventricle to the right atrium

bicuspid valve
(mitral valve)
prevents backflow of blood from the left ventrical to the left atrium

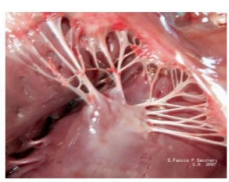
The tricuspid and bicuspid valves (atrio-ventricular valves) are between the atria and ventricles



Right side - Tricuspid valve

Left side - Bicuspid/Mitral valve

chordae tendineae
- inelastic cords of tissue that connect the tricuspid valve and bicuspid valve to the walls of the ventricles
- allow the valves to open and close in the correct positions



BLOOD FLOW THROUGH THE HEART

1. Both atrial and ventricular muscles are relaxed.
2. Blood enters atria and blood also starts flowing passively into the ventricles when the bicuspid and tricuspid valves open
3. The atria muscles contract, forcing the remaining blood in to the relaxed ventricles.
4. After a short pause, the ventricle muscles contract. The semi-lunar valves (aortic and pulmonary valves) are forced open.
5. Bicuspid and tricuspid valves forced close.
6. Blood flows from the right ventricle and left ventricle into the pulmonary artery and aorta respectively.
7. Semi-lunar valves forced close.
8. The atria muscles relax and now receives blood. The right atrium receives blood from the vena cava and the left atrium receives blood from the pulmonary vein.
9. The ventricle muscles relax, and the atrio-ventricular valves (bicuspid and tricuspid valves) open, and blood flows from the atria to the respective ventricles
10. Both atria and ventricle muscles relax.

the cardiac cycle — pathway of blood through heart

- oxygenated blood from lungs to enter left atrium via the pulmonary vein
  1) some blood starts to flow passively into the left ventricle
  2) the left atrial muscles contract
  3) this leads to higher pressure in the left atrium than the left ventricle
  4) the bicuspid valve is forced open and blood enters the left ventricle
- left ventricle muscles contract
  1) pressure in left ventricle becomes higher than pressure in aorta
  2) semi-lunar valve in aorta forced open + bicuspid valve forced close
  3) oxygenated blood flows via the aorta to the rest of the body
  4) blood entering the aorta is at a very high pressure
- deoxygenated blood from various parts of the body (other than lungs) returns to right atrium via the vena cava
  1) following this, the right atrium muscles contract
  2) pressure in the right atrium is higher than pressure in right ventricle
  3) tricuspid valve forced open when the blood flows into right ventricle
- right ventricle muscles contract and blood is pumped to the lungs
  1) pressure in right ventricle is higher than pressure in pulmonary artery
     a) semi-lunar valve in pulmonary artery forced open
     b) tricuspid valve forced close to prevent backflow of blood into atrium
  2) blood exits via pulmonary artery to the lungs
- semi-lunar valve prevents backflow of blood into right ventricle

blood pressure

- the force that blood exerts on the walls of blood vessels
- measured with sphygmomanometer in mmHg
- blood pressure in arteries highest during ventricular systole when blood is forced into arteries
- blood pressure decreases during ventricular diastole
- blood pressure is highest in the arteries, followed by the capillaries, and lowest in the veins
- blood pressure varies in different parts of the body and is highest near the heart; becomes weaker in arteries further away from the heart
- blood pressure is low in the veins, reaching almost 0 mmHg in vena cavae just before it opens into the right atrium

CORONARY HEART DISEASE

- coronary arteries: lie outside the heart, and transports blood to the heart muscles
- coronary heart disease
  - ↳ the narrowing or blockage of the coronary arteries, reducing blood supply to the heart muscles
1) this reduces the supply of glucose and oxygen to the heart muscles
2) coronary arteries can be blocked by fatty deposits or blood clot, causing the lumen of the arteries to be narrowed
   - ↳ atherosclerosis: caused by deposits of fatty substances on the inner surface of the arteries
   - ↳ thrombosis: blood clot trapped in artery
3) narrowed or blocked coronary arteries lead to reduction in blood flow to the heart muscles
4) blood supply to heart muscle is greatly reduced, reduces supply of glucose and oxygen to the heart muscles
5) heart muscle cells not able to carry out aerobic respiration efficiently, decreasing the release of energy for the heart muscle cells
   - ↳ ↑ risk of heart attack, when the heart muscle cells die, and the heart can no longer pump blood

possible causes of coronary heart disease
- diet rich in saturated fats and cholesterol
- sedentary lifestyle
- smoking

★ stress is not a cause of CHD!

preventive measures against coronary heart disease
- reduce intake of food high in cholesterol and saturated animal fats
  - ↳ replace with polyunsaturated fats
- do not smoke
  - ↳ nicotine and carbon monoxide in cigarette smoke ↑ risk of CHD

regular exercise
- ↳ strengthens the heart muscles and maintains elasticity of arterial walls