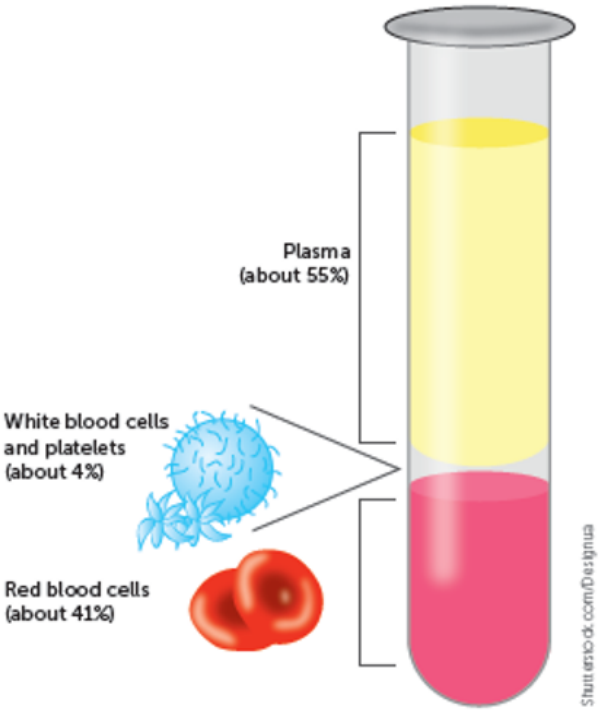
The circulatory system transports materials throughout the body

18/03/22

5.1 Blood as a transport medium

- Blood is composed of
  - Plasma: the liquid part
  - Formed elements: the non liquid part, consisting of erythrocytes (red blood cells), leukocytes (white blood cells) and thrombocytes (platelets)



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Plasma

- Mixture of water with dissolved substances
  - sugar and salts
- Function of plasma is to transport the components of blood
  - nutrients, water, hormones, proteins and antibodies, throughout the body

Erythrocytes

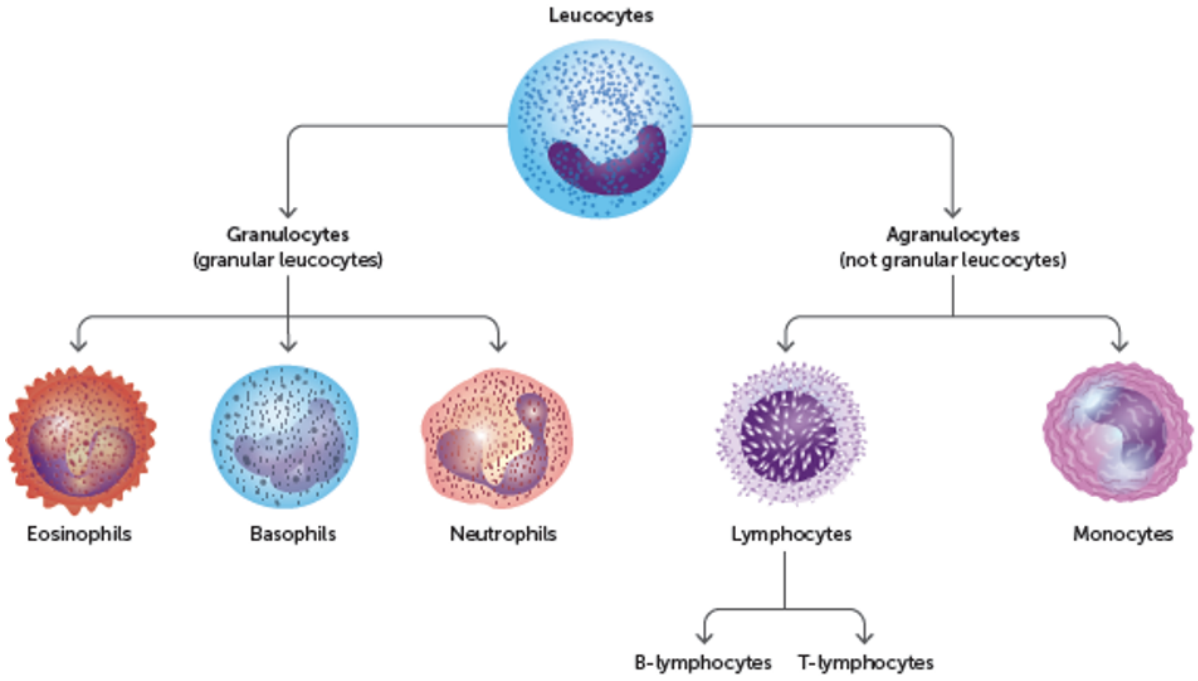
- Or red blood cells, are the most abundant cells in the blood
- Cells are a biconcave shape
  - flattered in the middle on both sides
- Don't contain nucleus, which increases flexibility and, hence, their ability to move through blood vessels
- The lack of nucleus also limits their life span to only 120 days on average
- The function of erythrocytes is to transport oxygen from lungs to the cells throughout the body

Leukocytes

- White blood cells
- Protects the body from infection
- Makes up 1% of the blood
- Larger than RBC
- Number of different leuko, each with its own structure and function
    - Neutrophils
    - Monocytes
    - Lymphocytes
    - Basophils
    - Eosinophils

Thrombocytes

- Platelets
- Small fragment of cells
- When blood vessel is injured, platelets adhere to the lining and form a scaffold for the coagulation of the blood to form a clot



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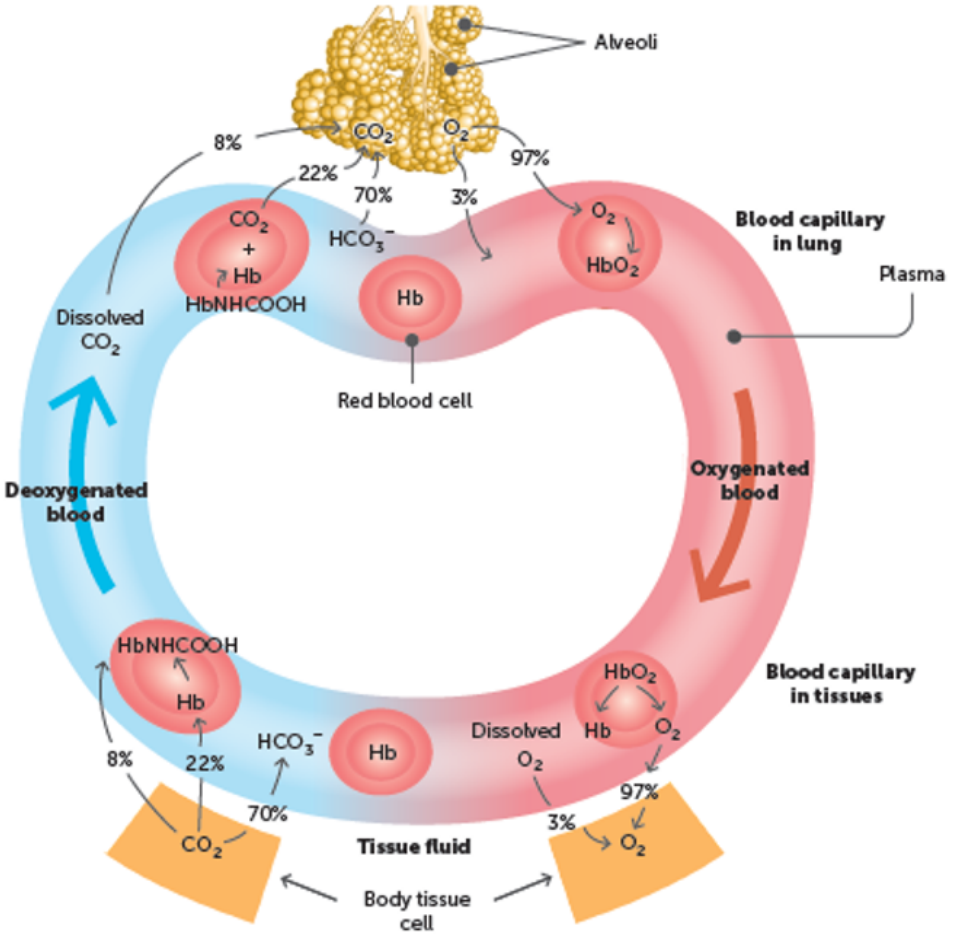
Transport of oxygen

- Majority of oxygen is transported on erythrocytes as oxyhemoglobin
- RBC are well suited to their function of oxygen transport because they:
    - contain haemoglobin, which is able to combine with oxygen
    - have no nucleus, so there's more room (surface area) for haemoglobin molecules
    - shaped like biconcave discs
        - biconcave centre increases SA for oxygen exchange and the thicker edges give a large volume that allows room for the haemoglobin molecules

Transport of carbon dioxide

- Can be transported by dissolving in plasma (7-8%), as carbaminohaemoglobin (22%) or as bicarbonate ions (70%) in the plasma



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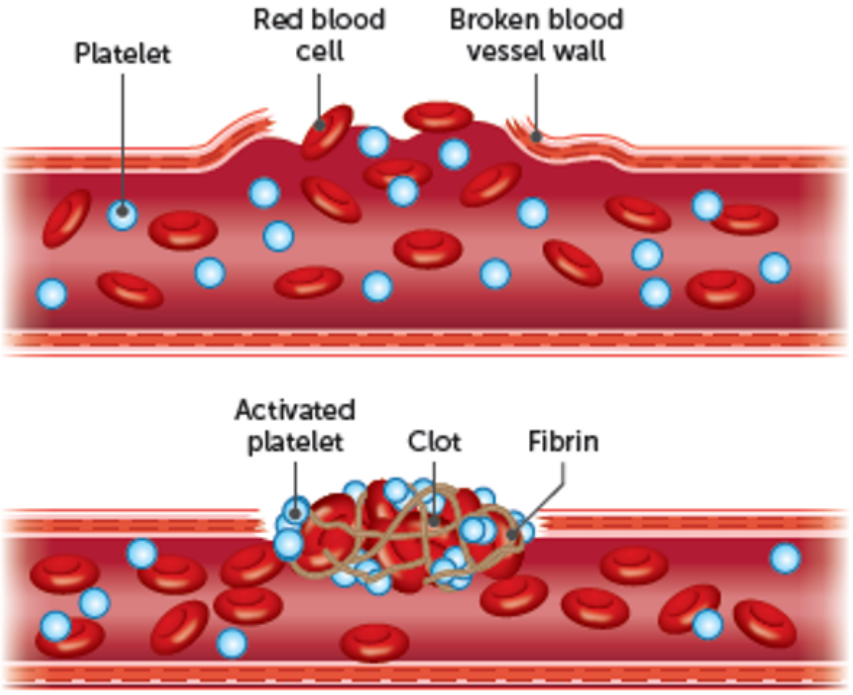
Transport of nutrients and waste

- Nutrients and wastes (apart from CO2) are dissolved and transported in the blood plasma
- Nutrients are essential elements and the molecules that are obtained from the food we eat
- Inorganic nutrients are transported as ions
- Some of the important ions dissolved in the blood plasma
    - sodium ions (NA+), calcium ions (Ca2+), potassium ions (K+), chloride ions (Cl-) and iodide ions (I-)
- Organic nutrients dissolved in the plasma
    - Glucose, vitamins, amino acids, fatty acids and glycerol
- Metabolic wastes are substances produced by the cells that cannot be used and would be harmful if allowed to accumulate
- The most important organic wastes that are transported in solution in the blood plasma are urea, creatinine and uric acid

Blood clotting

- Helps to minimise blood loss and prevent infection after an injury that causes damage to blood vessels, it involves:
    - 1. Vasoconstriction

- 2. Platelet plug
- 3. Coagulation



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5.2 Moving blood through the body

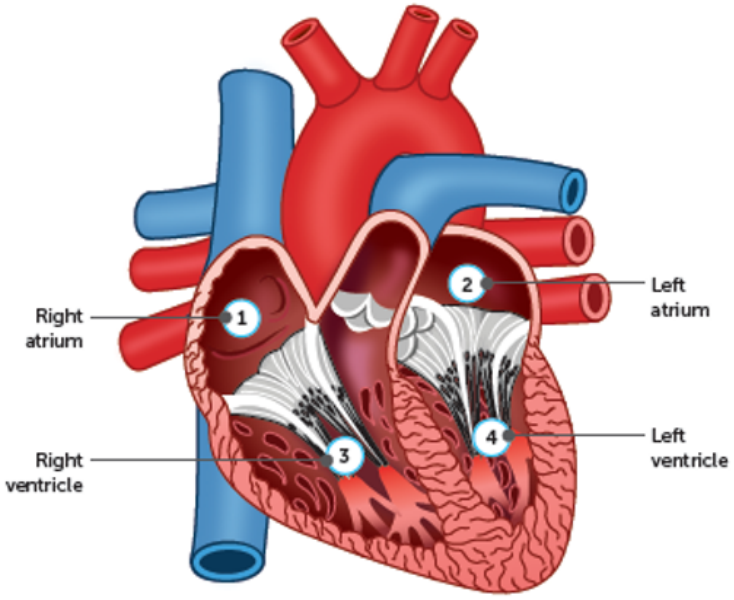
The heart

- The pump that pushes the blood around the body and is located between the two lungs in the mediastinum
- Completely enclosed in a membrane called the pericardium, which holds the heart in place, but also allows the heart to move as it beats. Walls are made up of cardiac muscle
- Left and right sides of the heart are separated by a wall called the septum.
    - Ride side collects blood from the body and pumps it to the lungs,
    - left side received the blood from the lungs and pumps it to the rest of the body

Heart chambers

- four chambers in the heart
    - top chambers
        - atria
    - bottom chambers
        - ventricles
- The right atrium
    - receives blood from the body and passes it to the right ventricle
- The right ventricle
    - pumps blood to the lungs
- The left atrium
    - receives blood from the lungs and passes it to the left ventricle

- The left ventricle
    - pumps blood to the body



Heart valves

- Valves are located between the atria and the ventricles (atrioventricular valves), and at the exit of the ventricles (semilunar valves). They act to stop blood from flowing backwards.

TYPE OF VALVE	NAME OF VALVE	LOCATION	NUMBER OF FLAPS OR CUSPS
Atrioventricular valve	Tricuspid valve	Between the right atrium and right ventricle	3
	Mitral (bicuspid) valve	Between the left atrium and left ventricle	2
Semilunar valve	Pulmonary valve	Between the right ventricle and pulmonary artery	3
	Aortic valve	Between the left ventricle and the aorta	3

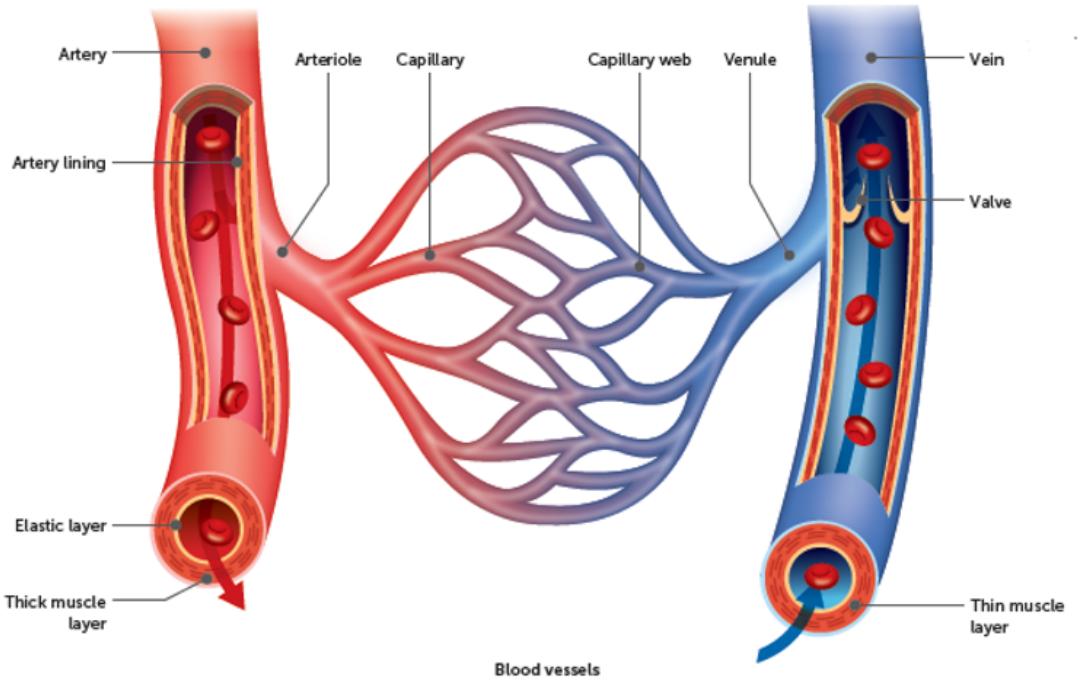
Blood vessels

- Blood is pumped by the heart into blood vessels, which carry the blood to the cells of the body or the lungs, and then bring it back to heart again.
- The same blood flows continuously through the heart, and this movement of blood if referred to as the circulation
- Three main types of blood vessels that are joined together to form the channels through which the blood flows:
    - arteries
    - capillaries
    - Veins

Arteries

- Blood vessels that carry blood away from the heart

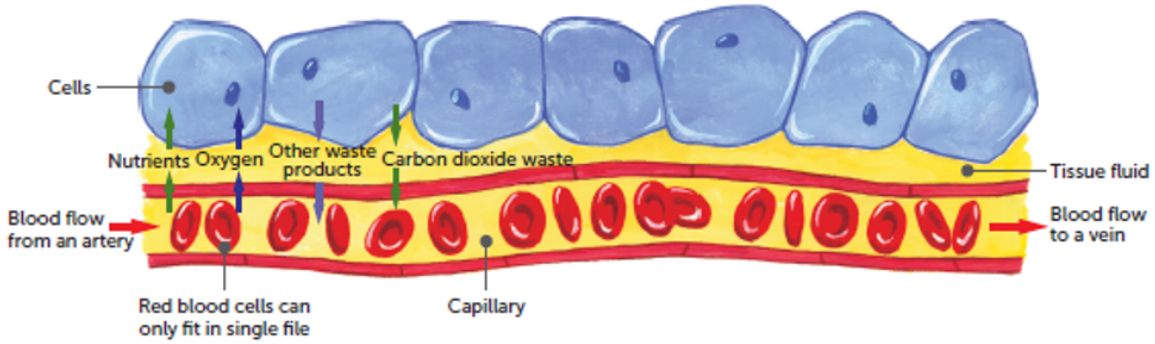
- Large artery called aorta
    - takes blood from the left ventricle to the body
- Another important artery called pulmonary artery
    - takes blood from the right ventricle to the lungs.
    - Smooth muscle in their walls
- The very large arteries called arterioles
    - receive blood pumped by the ventricles divide into smaller arteries, which in turn divide into very small arteries
    - Supplies blood to the capillaries



Blood vessels

Capillaries

- link between the arteries and veins
- Microscopic blood vessels that form a network to carry blood close to nearly every cell in the body.
- Enables cells to get their requirements from the blood and to pass their waste into the blood
- Capillary walls have only one layer of cells, which allows substances to pass easily between the blood and the surrounding cells.



Veins

- carry blood towards the heart
- Capillaries join into small veins, venues, which then join up to make larger veins. These culminate in:
    - inferior vena cava and superior vena cava, which bring blood from the body to the right atrium
    - pulmonary veins, which brings blood from the lungs to the left atrium.
        - four pulmonary veins
            - two from each lung
    - Don't have muscular walls. Blood pressure in the veins is relatively low so many veins have valves to prevent the blood from flowing backwards

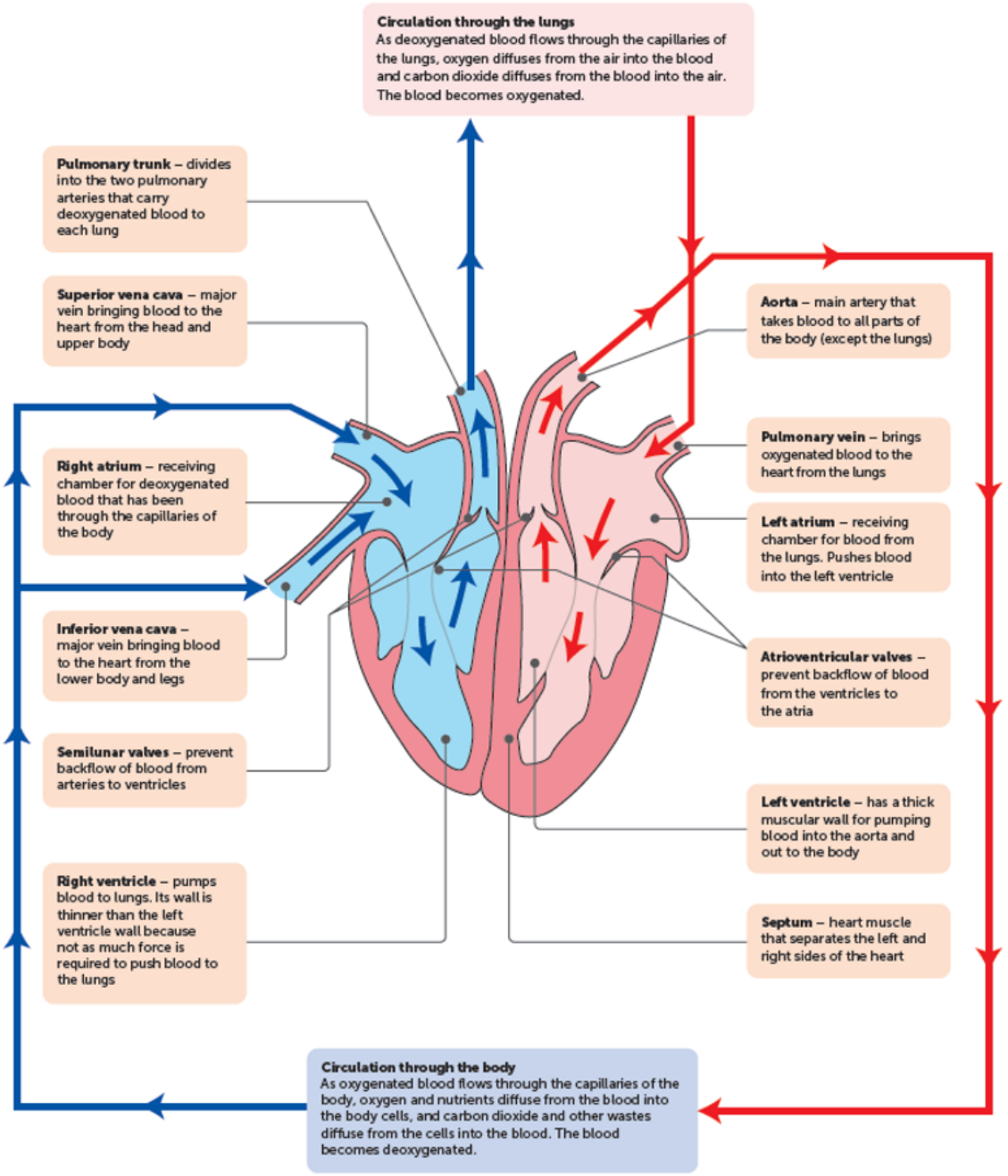
Blood flow

- The requirements of cells vary depending on their level of activity, therefore the blood flow to and from the cells must be able to change. Two ways this can occur:
    - by changing the output of blood from the heart
    - by changing the diameter of the blood vessels supplying the tissues

Cardiac cycle

- Or heartbeat, is the sequence of events that occurs in one complete best of the heart
- Systole
    - The pumping phase of the cycle, when the heart muscle contacts
- Diastole
    - The filling phase, as the heart muscle relaxes. For a short time both atria and ventricles are in **diastole**.
- During this phase, the atria fill with blood and the ventricles also receive blood as the valves between them are open. **Atrial systole**, the contraction of the atria, then follows and forces the remaining blood into the ventricles. The atria then relaxes and refills while the ventricles contract in the ventricular **systole.**
- Ventricular systole
    - forces blood into the arteries.
    - Left and right side of the heart are two pumps, they operate together. Both atria contract simultaneously, as do both ventricles

Structure of the heart and circulation of the blood



Cardiac output

- How quickly the blood flows around the body depends on how fast the heart is beating and how much blood the heart pumps with each beat.
- The heart rate is the number of times the heart beats per minute, while the stroke volume is the volume of blood forced from a ventricle of the heart with each contraction
- A combination of both these factors influences the cardiac output
    - the amount of blood leaving one of the ventricles every minute.
    - The cardiac output is equal to the stroke volume multiplied by the heart rate:
    - Cardiac output (mL/minute) = stroke volume (mL) x heart rate (beats/minute)

5.3 Blood groups and transfusions

Blood groups

- Antigen
    - Surface of red blood cells is coated with sugar and protein molecules that are able to stimulate the immune system.
- Antibody
    - protein produced by the immune system
- The antigen and antibody combine to form a complex and cause a reaction
- There are a number of blood group systems, but the ABO and Rh groupings are particularly important in blood transfusions.

ABO blood groups

- Two sugar antigens involved in the ABO classification:
    - antigen A and antigen B
- On the surface of the RBC a person may have either antigen A, antigen B, both antigens or neither antigen
- Four possibilities correspond to the four groups of the ANO system:
    - group A (antigen A), group B (antigen B), group AB (both antigens) and group O (neither antigen)
    - The body’s ability to make the antigens, and so a person's ABO blood group is determined by their DNA and is therefore inherited
    - The antibody that reacts against antigen A is called anti-A, and anti-B reacts against antigen B. A person's immune system is able to recognise their own antigens and will not produce antibodies for them, but will produce antibodies for antigens that are non self.

Rh blood groups

- Rhesus blood group system
- based on antigens that occur on the surface of the red blood cells.
- Rh antigens are proteins
- A person with Rh antigens is said to be Rh positive;
    - a person without these antigens is Rh negative. An individual without the Rh antigens is an,e to produce an anti- Rh antibody that reacts against those antigens. Rh-positive individuals cannot produce an anti-Rh antibody

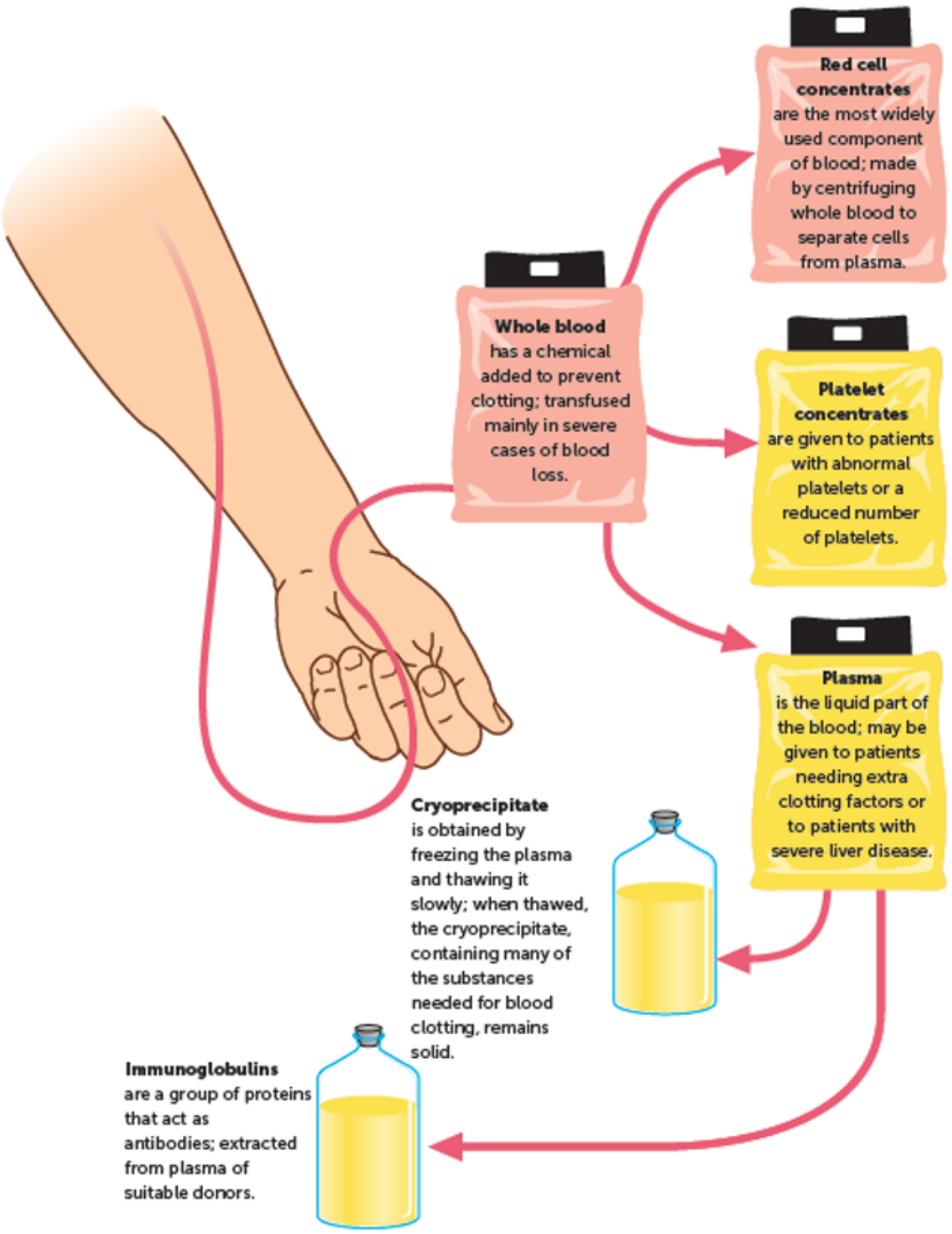
Transfusions

- Blood transfusion can be given to a person suffering from excessive blood loss, some types of anaemia, leukaemia, haemophilia or other conditions.
- It involves blood, or a blood product, from a donor being injected directly into the patient's bloodstream
- For most transfusions it is necessary to match the ABO and Rh blood groups of the donor and the recipient.

BLOOD GROUP	ANTIGENS ON RED BLOOD CELLS	ANTIBODIES IN PLASMA	ABLE TO DONATE TO PEOPLE WITH BLOOD GROUP ...	ABLE TO RECEIVE BLOOD (RED CELL CONCENTRATE) FROM PEOPLE WITH BLOOD GROUP ...
A	Antigen A	Anti-B	A, AB	A, O
B	Antigen B	Anti-A	B, AB	B, O
AB	Antigen A and antigen B	Neither anti-A nor anti-B	AB	A, B, AB, O
O	Neither antigen A nor antigen B	Both anti-A and anti-B	A, B, AB, O	O

Types of transfusions

- Different types of blood transfusions are used for different conditions. They include:
  - Whole blood
  - red cell concentrates
  - platelet concentrates
  - cryoprecipitate
  - immunoglobulins
  - autologous transfusion

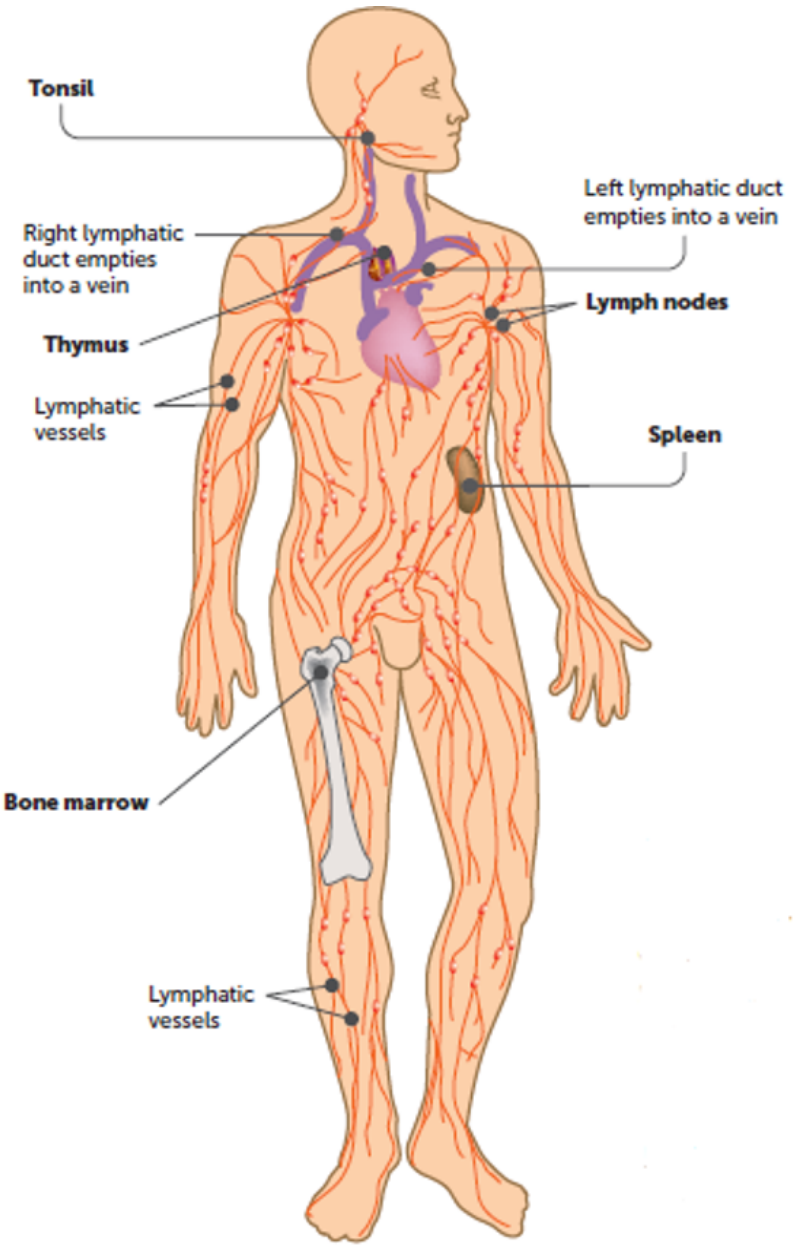


5.4 The lymphatic system

- Main function is to collect some of the fluid in the blood that escapes from the blood capillaries and return it to the circulatory system
- Important part of the body's internal defence against disease causing organisms

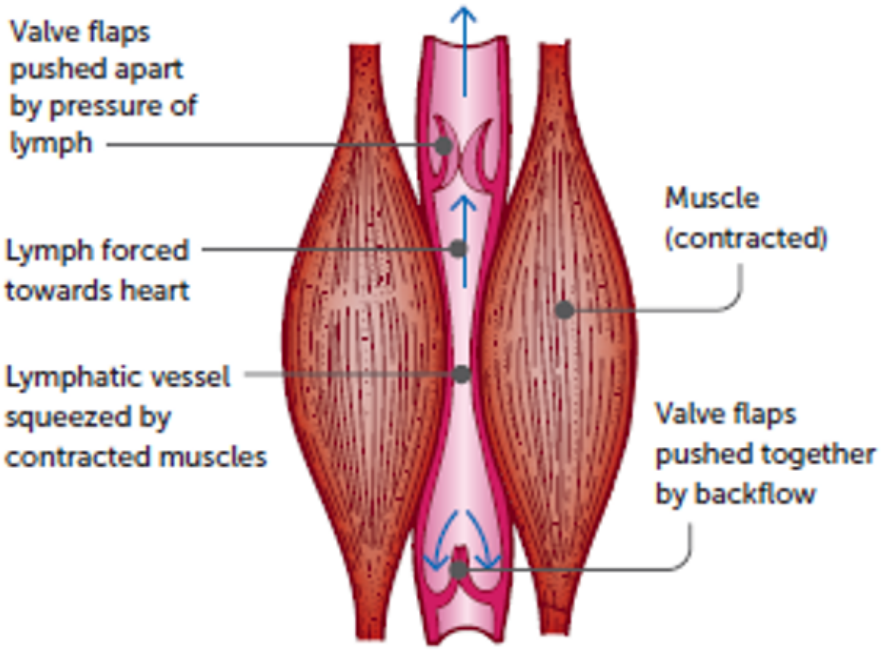
Structure

- a networked of lymph capillaries joined to larger lymph vessels (also called lymphatic vessels or lymphatics)
- lymph nodes, which are located along the length of some lymph vessels



Lymph vessels

- fluid that is collected from between the cells and transported in lymph vessels to the large veins
- Lymphatic system is a one way system carrying fluid away from the tissues. The lymph vessels originate as blind ended tubes in the spaces between the cells of most tissues
- The network of ly oh vessels joins to form two lymphatic ducts that empty the lymph into large veins in the upper chest
- Lymph is moved through the lymphatic vessels as a result of smooth muscle, skeletal muscle and valves



Lymph nodes

- AKA lymph glands
- occurs at intervals along the lymphatic vessels
- Most numerous in the neck, armpits, groin and around the alimentary canal
- Nodes are bean chapped and range in length from 1mm to 25mm. Each is surrounded by a capsule of connective tissue that extends into the mode, forming a framework. Wishing the framework are masses of lymphoid tissue, containing cells known as lymphocytes, macrophages and plasma cells. These cells help protect the body against disease
- Lymph enters through vessels on the convex side of the node, filters through the spaces and passes out through vessels on the opposite side. The lymph passes through several nodes before entering the circulatory system.