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Competency

The learner appreciates that animals have special systems for the efficient transport of materials around their bodies, and understand the principles of how these systems operate

Learning outcomes

The learner should be able to;

a) understand the principle of the surface area to volume ratio (s)

b) know the need for a transport system, and identify the components involved in the transport system in mammals.

c) describe the structure of the heart and how it functions.

d) understand how structure of blood vessels are related to their function by comparing arteries, veins and capillaries.

e) identify the major functions of blood, and relate the functions to the components of blood.

f) understand the causes and prevention of diseases associated with the heart (high blood pressure, coronary heart disease and stroke).

g) understand the importance of knowledge of blood groups for blood transfusion.

h) appreciate the role of blood in the defence of the human body (u)

i) know how immunity is weakened by various infections including HIV.

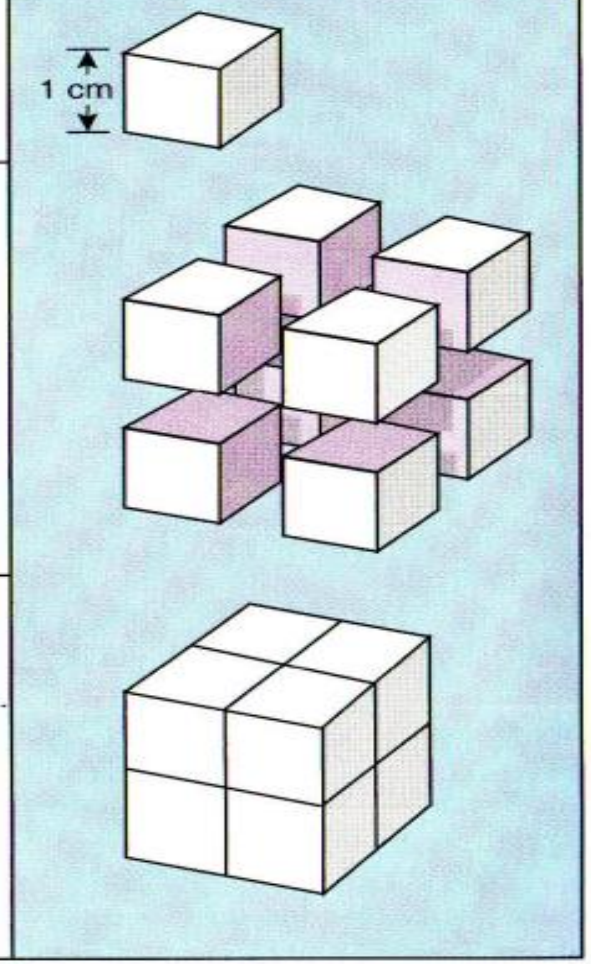
j) understand the process of the formation of lymph and its flow around the body.

k) appreciate the function of the lymphatic system in maintaining a healthy body (u)

TRANSPORT IN ANIMALS

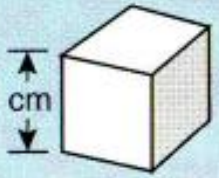
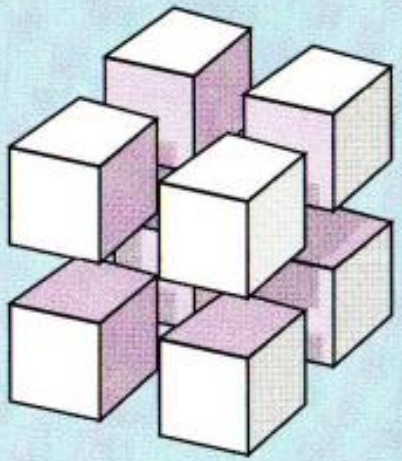
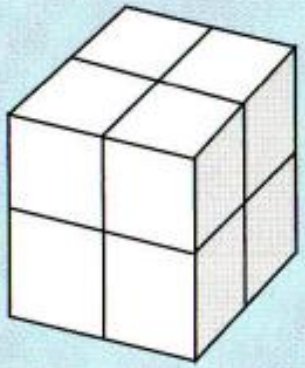
- Transport is the movement of materials from one part of the organism to another.
- Materials transported include oxygen, carbon dioxide, soluble food substances, hormones, waste products such as urea, etc.
- Transport in organisms involves processes like diffusion, osmosis, and active transport.
- In unicellular and simple multicellular organisms the above processes are enough to meet the transport requirements since materials are only transported over very short distances.
- Larger and more complex animals require transport systems (circulatory system) for effective transport over long distances

The principle of the surface area to volume ratio

Volume	Surface area	S/V ratio	
1 cm^3	6 cm^2	6:1	
8 cm^3	48 cm^2	6:1	
8 cm^3	24 cm^2	3:1	

Consider;

- A cube that is 1 cm on a side (top) has a volume of 1cm3 and because it has 6 sides, a surface area of 6cm3.
- 8 such cubes (middle) will, of course have both 8 times the surface area, so the ratio of the surface area to the volume of the cubes, or surface-to-volume (S/V) ratio, will stay the same: 6:1.
- If the 8 cubes are combined into a single large one (bottom) , half the surface are hidden in the interior.
- The (S/V) ratio, like the surface area is reduced by half, to 3:1.
- A large cube, therefore, has a lower S/V ratio than a small one.

Volume	Surface area	S/V ratio	
1 cm^3	6 cm^2	6:1	
8 cm^3	48 cm^2	6:1	
8 cm^3	24 cm^2	3:1	

The principle of the surface area to volume ratio in relation to organisms

- Organisms and cells exchange nutrients, waste products, and gasses (O2, CO2) with the environment.
- Such materials have to move across the surface of a cell, so the amount of surface area is very important. More precisely, it is the amount of surface area relative to the total volume of the cell.
- This is called the surface to volume ratio, or the S/V ratio. The S/V ratio determines how rapidly materials can flow into and out of a cell or how rapidly heat can be lost from a large mammal.

- The illustration on the previous page shows that a larger cube has less surface area exposed in proportion to volume. Functionally this means that as an object becomes larger, it has less surface area relative to volume.
- Cell size is limited by surface to volume ratios. A single cell or a single celled organism relies on diffusion across the cell surface for exchange of materials.
- Beyond a certain volume, a cell would not have enough surface area to import and export all the materials it needs. This effectively sets an upper limit of how big cells can be and helps explain why most cells in an elephant are no bigger than those in a mouse, although an elephant has more cells than a mouse.
- Larger organisms must develop supplementary mechanisms, like respiratory, circulatory, and excretory systems to transport oxygen and nutrients to cells and remove wastes

The need for a transport system in larger organisms

- ✓ Large organisms require a lot of materials and produce large amounts metabolic wastes. A transport system is therefore important in these organisms for bulk transport of the materials.
- ✓ The larger the organism, the longer the distance from the outer body surface/surfaces to the center/middle of the body. Thus materials have to be moved over long distances between the inner cells and the body surfaces for exchange with environment for which simple processes such as diffusion are not effective over long distances. Thus a transport system is required for the transport of materials.
- ✓ The larger an organism becomes, the smaller the surface area to volume ratio which reduces the rate of diffusion of materials from the body surface to the cells in the middle of the organism. Thus a transport system is required for faster transfer of materials from the body surface to the cells in the middle of the organism.

COMPONENTS INVOLVED IN THE TRANSPORT SYSTEM IN MAMMAL

- Larger animals require a circulatory system to distribute materials efficiently. A circulatory system typically has the following components:

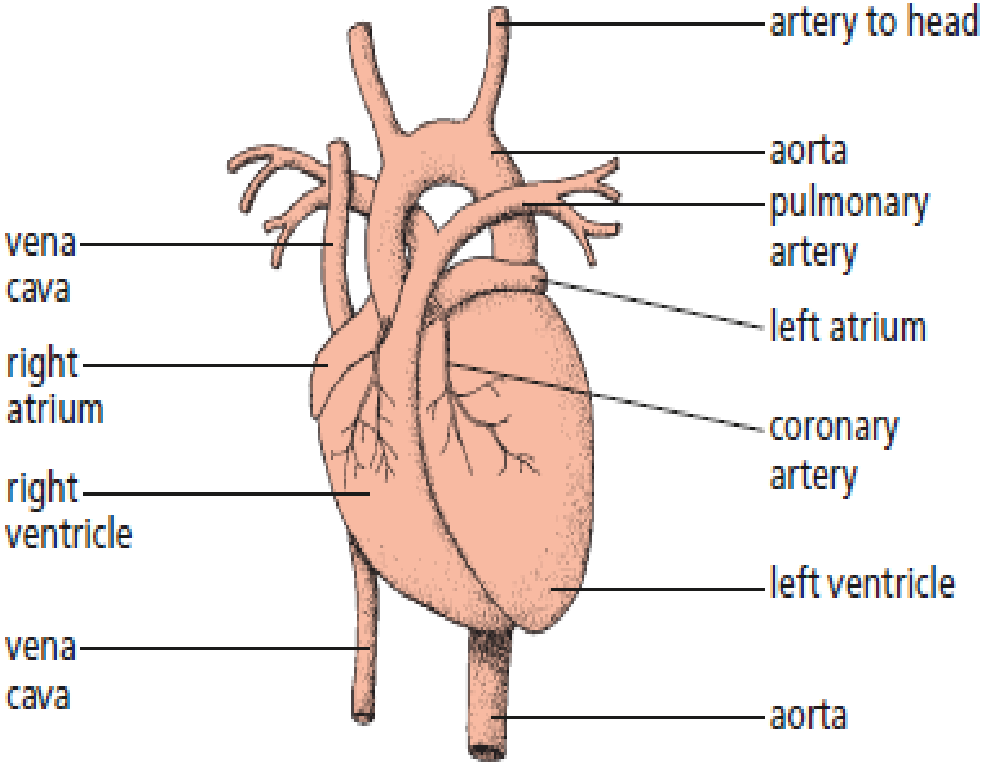
❖ **blood**, a connective tissue consisting of cells and cell fragments dispersed in fluid, usually called *plasma*.

❖ A pumping organ, generally a **heart** with **valves**; and

❖ A system of **blood vessels** or spaces through which blood circulates. systems are open and closed systems.

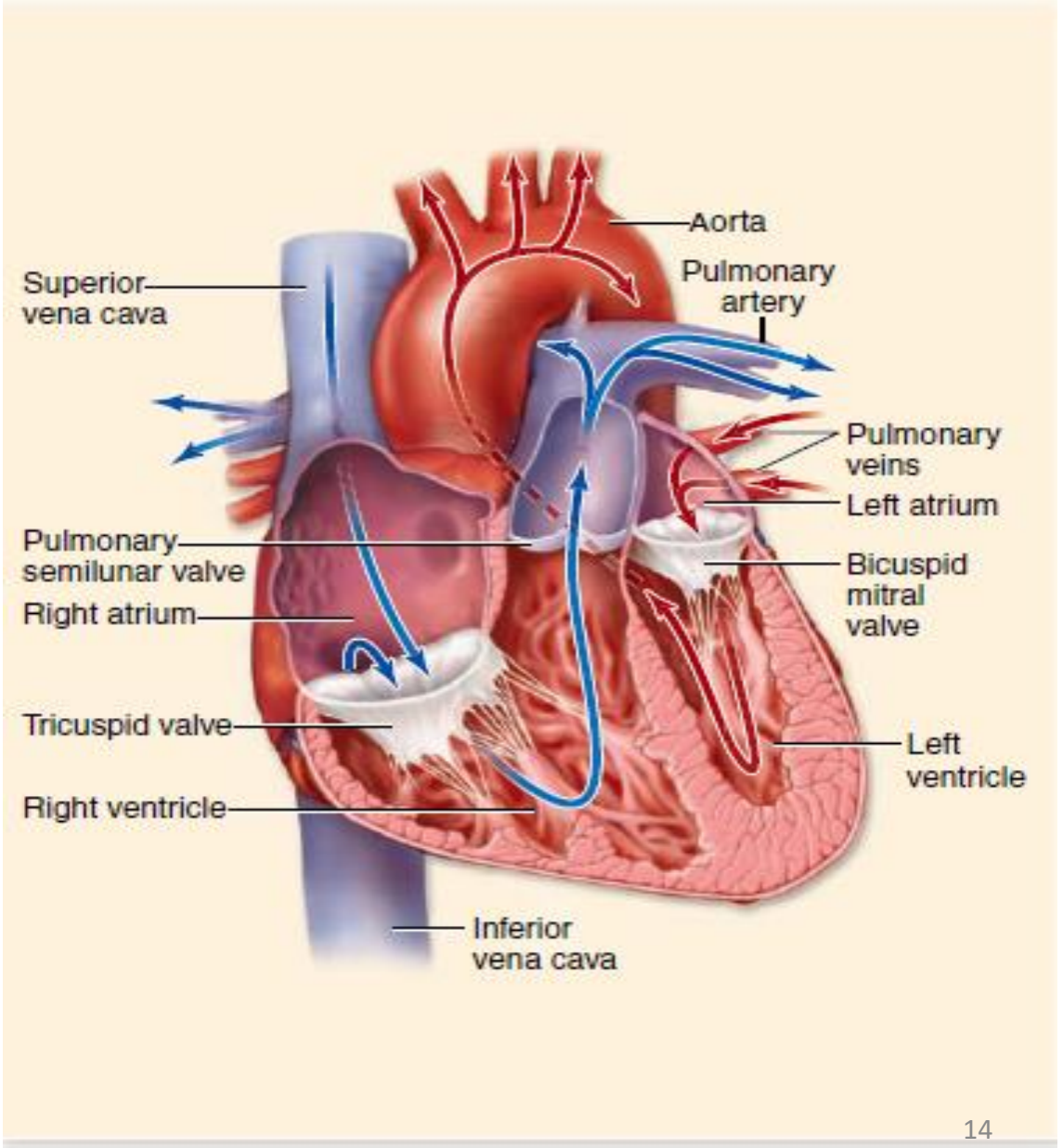
THE MAMMALIAN HEART

- The heart is a muscular pump with valves, which sends blood around the circulatory system.
- The heart pumps blood through the circulatory system to all the major organs of the body.
- Since the heart is seen as if in a dissection of a person facing you, the left side is drawn on the right.

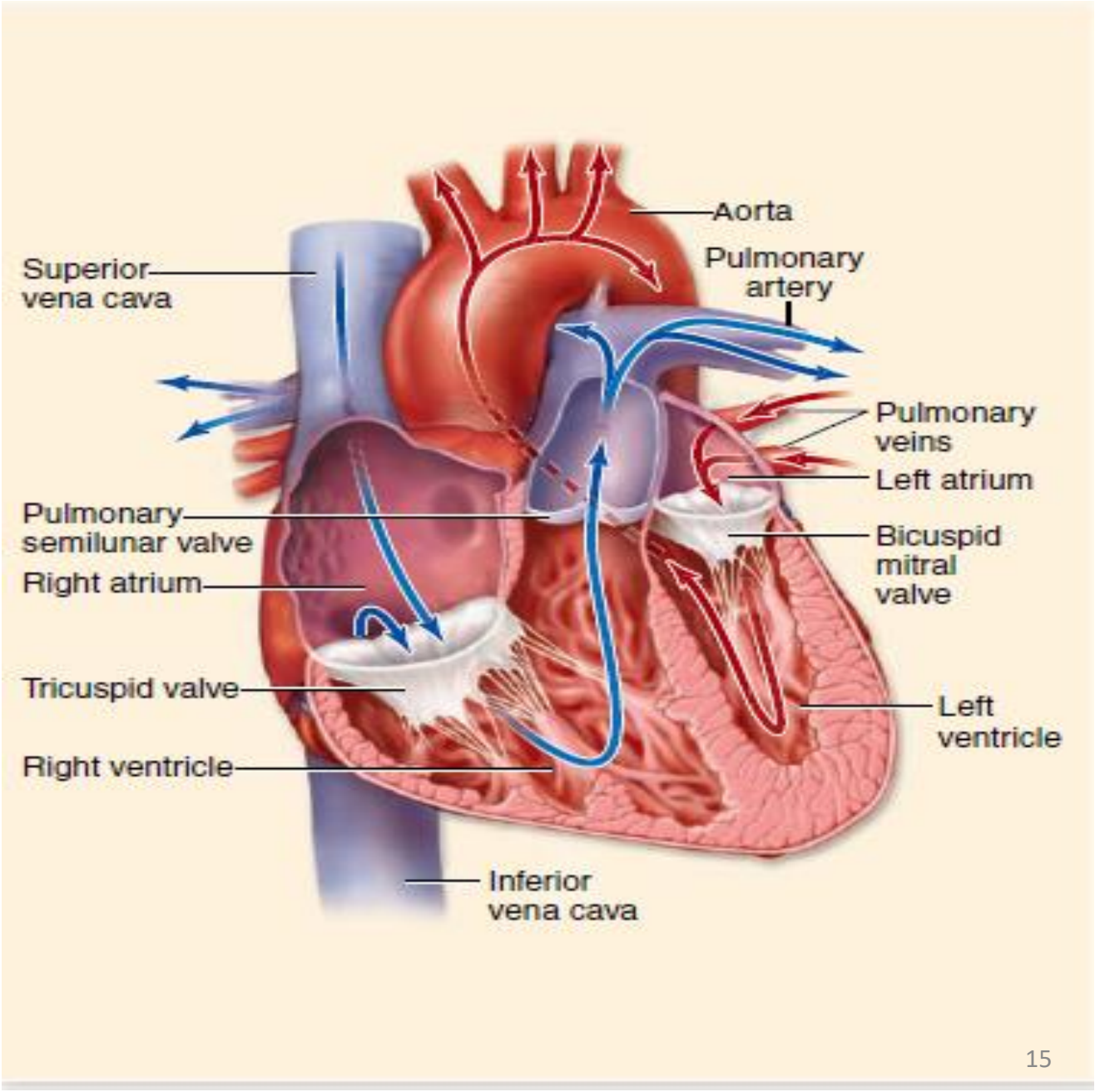


THE STRUCTURE OF THE MAMMALIAN HEART

- The whole heart is surrounded by the pericardium which has two layers between which is the pericardial fluid that reduce friction between them.
- The heart is made of tissues called cardiac muscles which have the potential to contract rapidly.
- It's divided in to four chambers. The upper chambers are called atrium / auricle and the lower chambers are each called ventricle.
- The heart is divided into sections i.e. left and right by a muscular septum whose function is to prevent mixing of oxygenated and deoxygenated blood.
- Movement of blood in the heart is maintained in a single direction i.e. from the auricle to ventricle and then to blood vessels.

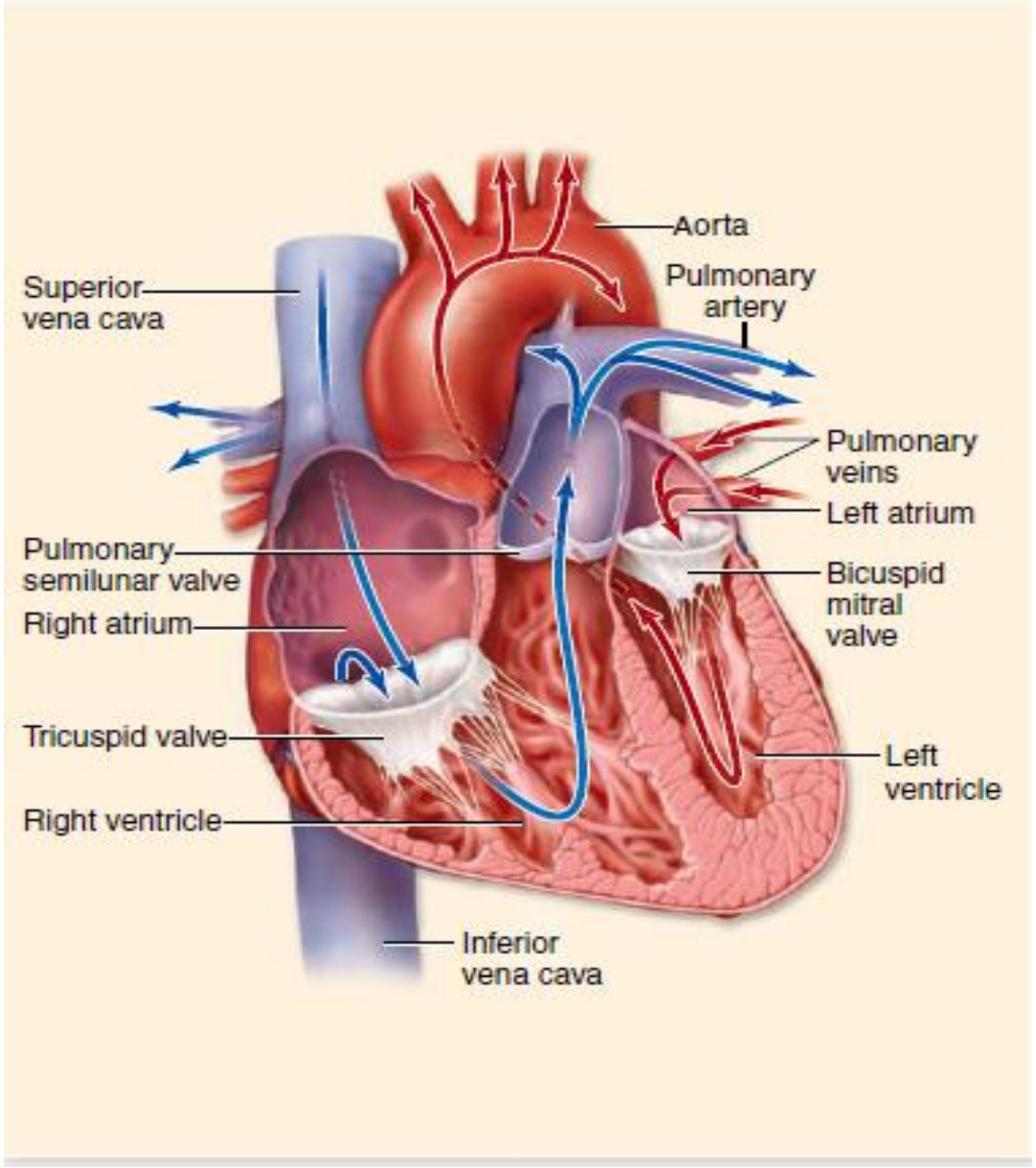


- The heart has four valves that ensure the one-way flow of blood.
- The atrioventricular (AV) valves separate the atria from the ventricles.
- **The tricuspid valve** is located between the right atrium and right ventricle, while **the bicuspid valve** is located between the left atrium and left ventricle.
- The semilunar valves, including the **aortic valve** and **the pulmonary valve**, are located between the ventricles and major blood vessels.
- These valves open and close to allow blood to flow in one direction and prevent backflow.

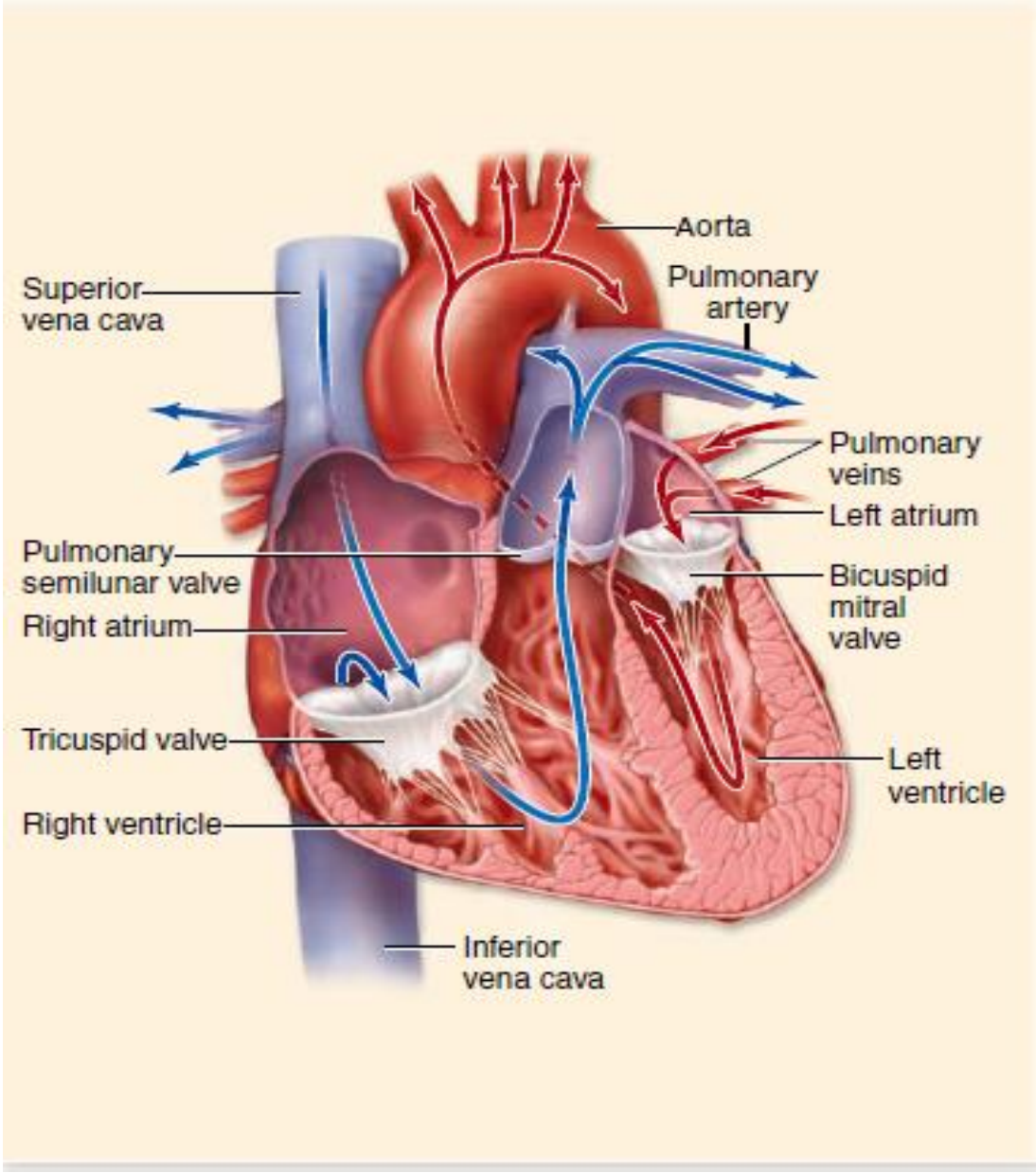


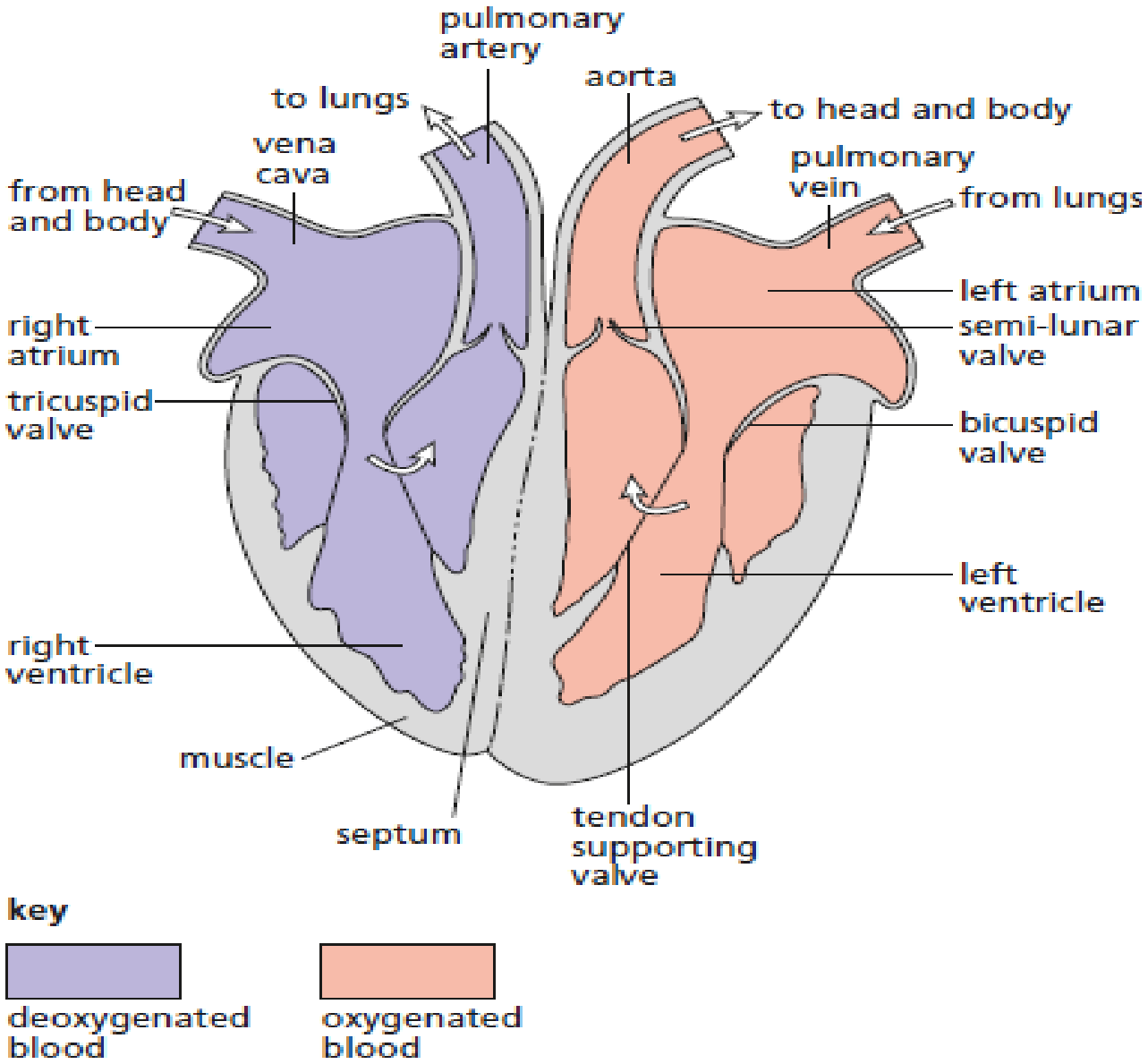
The heart is connected to major blood vessels that transport blood throughout the body.

- The aorta is the largest artery that carries oxygenated blood from the left ventricle to the rest of the body.
- The pulmonary artery carries deoxygenated blood from the right ventricle to the lungs for oxygenation.
- The pulmonary veins carry oxygenated blood from the lungs to the left atrium.
- The superior and inferior vena cavae bring deoxygenated blood from the body to the right atrium.



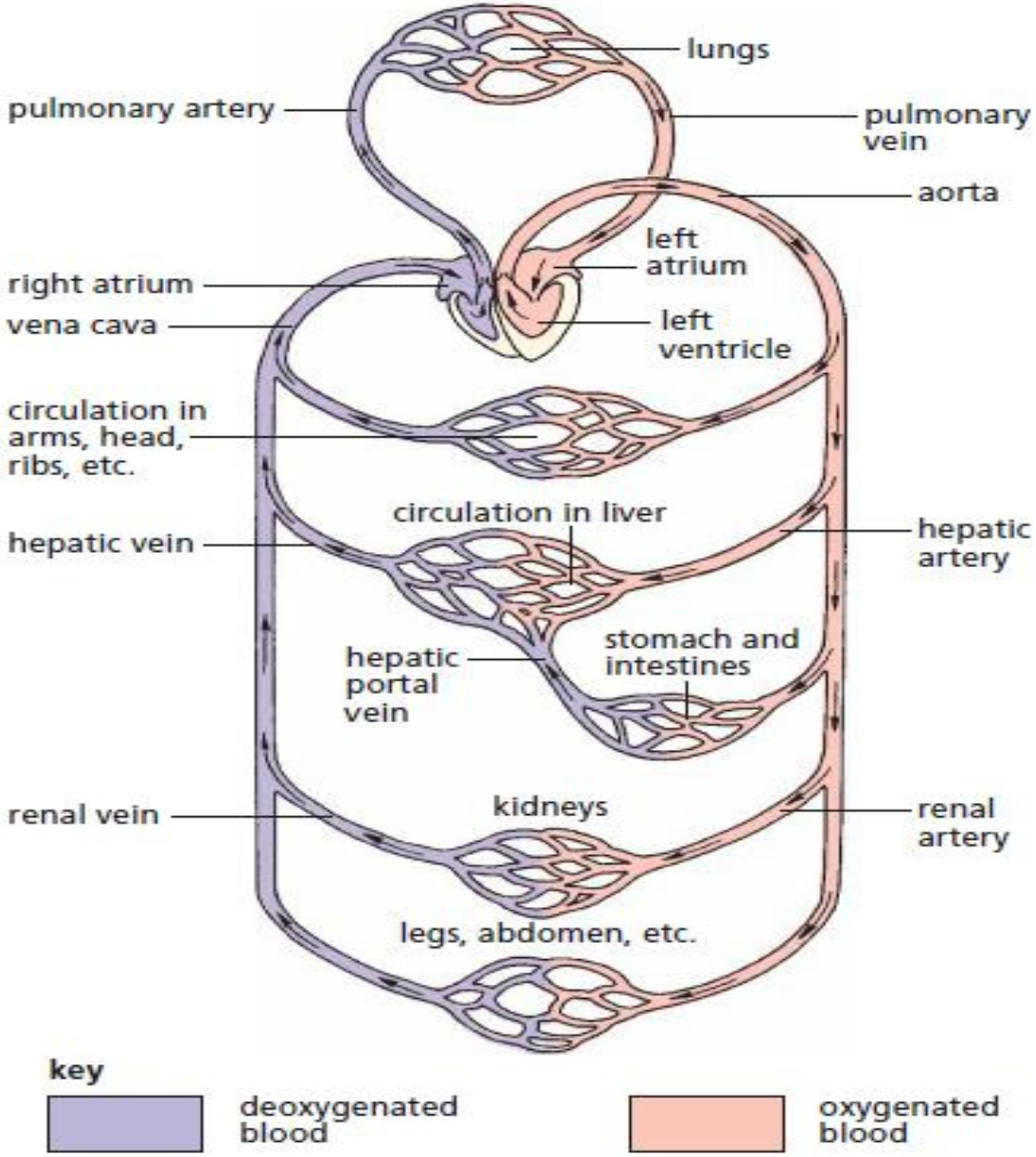
- The ventricle walls are more muscular (have thicker walls) than those or the auricles because the auricle pump blood to shorter distance i.e. to the ventricle while the ventricles pump blood longer distances i.e. to body and lungs.
- The walls of the left ventricle that pump blood in to the systemic circulation are thicker than those of the right ventricle which pump blood to pulmonary circulation.



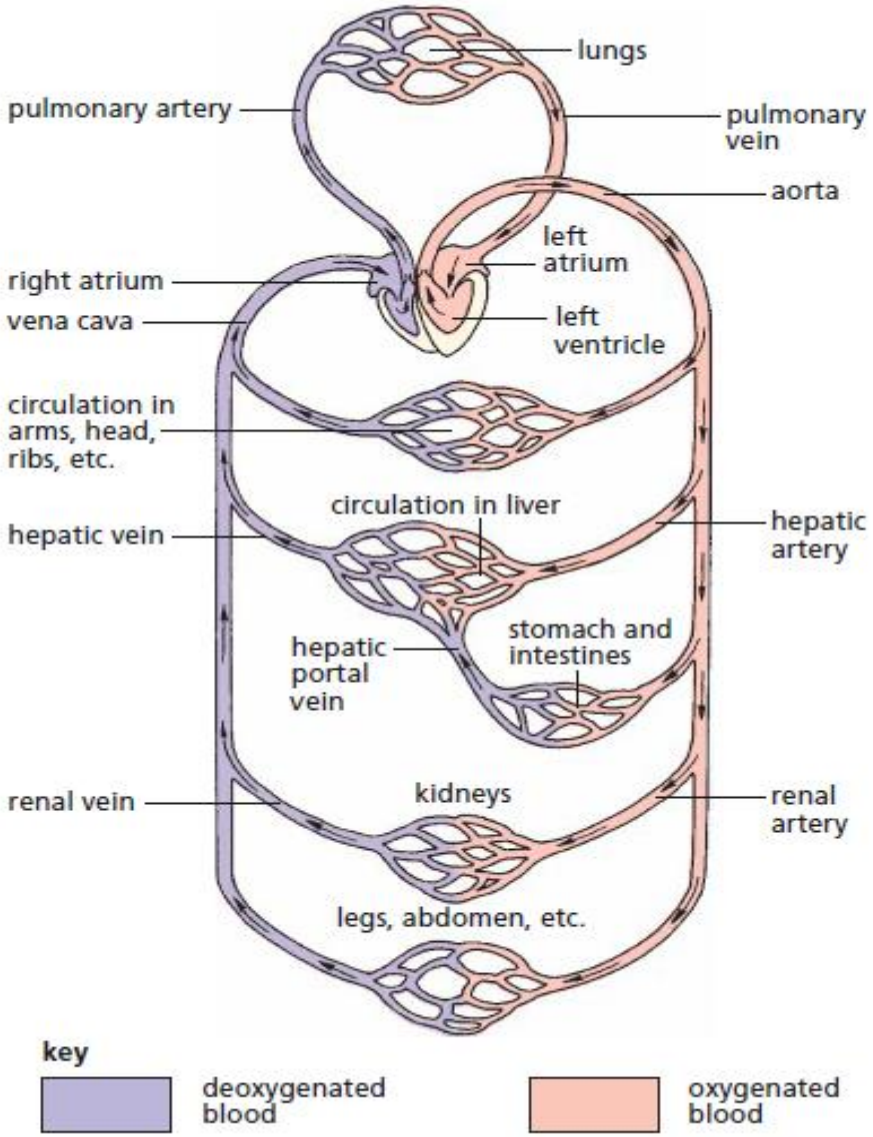

pulmonary artery
aorta
to lungs
to head and body
vena cava
pulmonary vein
from head and body
from lungs
left atrium
right atrium
semi-lunar valve
tricuspid valve
bicuspid valve
left ventricle
right ventricle
muscle
septum
tendon supporting valve
key
deoxygenated blood
oxygenated blood

How the heart functions (How blood flows through the mammalian heart

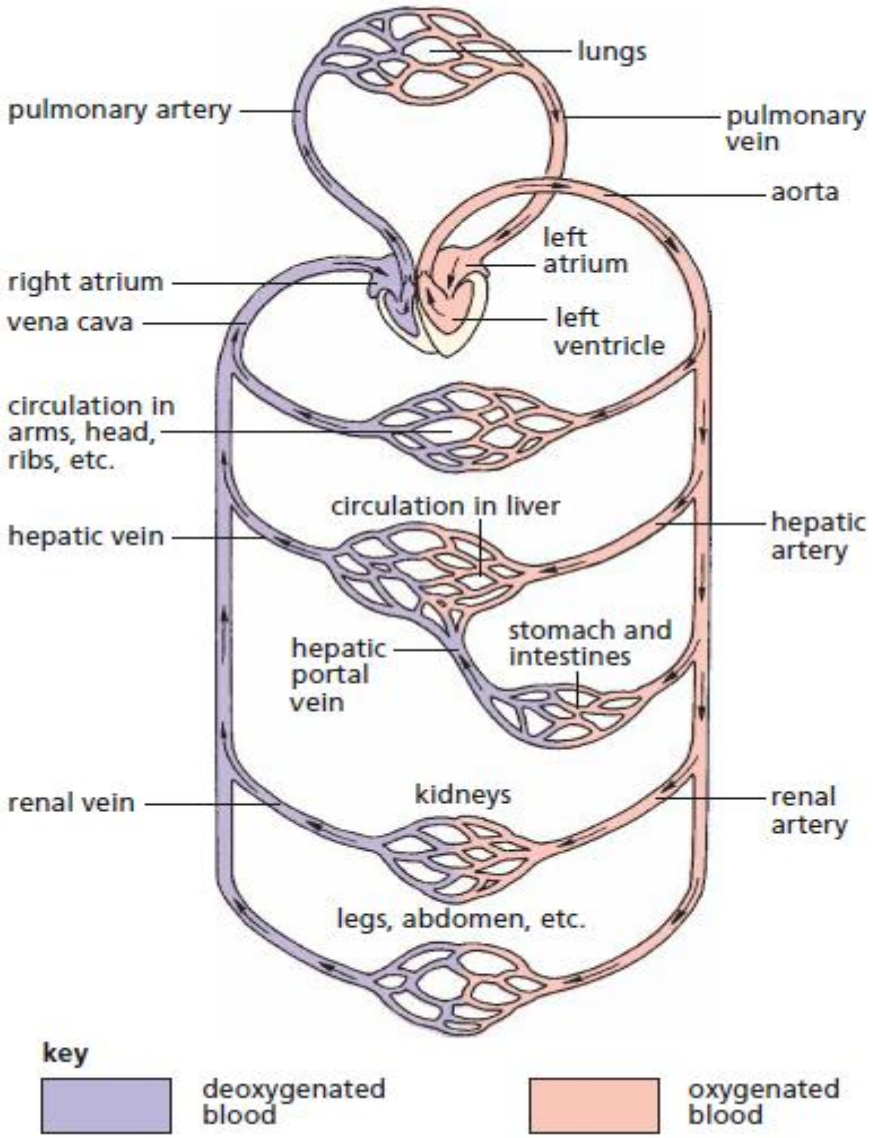
- The heart functions as a pump to circulate blood throughout the body. The process can be summarized in the following steps
- Blood enters the heart through the superior and inferior vena cavae, which bring deoxygenated blood from the body to the right atrium.
- The right atrium contracts, pushing blood through the tricuspid valve into the right ventricle.
- The right ventricle contracts, forcing blood through the pulmonary valve and into the pulmonary artery.



- The pulmonary artery carries the deoxygenated blood to the lungs, where it picks up oxygen and releases carbon dioxide.
- Oxygenated blood returns from the lungs to the left atrium via the pulmonary veins.
- The left atrium contracts, pushing blood through the mitral valve into the left ventricle.
- The left ventricle contracts, pumping oxygenated blood through the aortic valve and into the aorta, the largest artery in the body.



- The aorta branches into smaller arteries, which carry the oxygenated blood to the rest of the body.
- Capillaries, the smallest blood vessels, facilitate the exchange of oxygen and nutrients with tissues.
- Deoxygenated blood returns to the heart through veins, starting the process again.



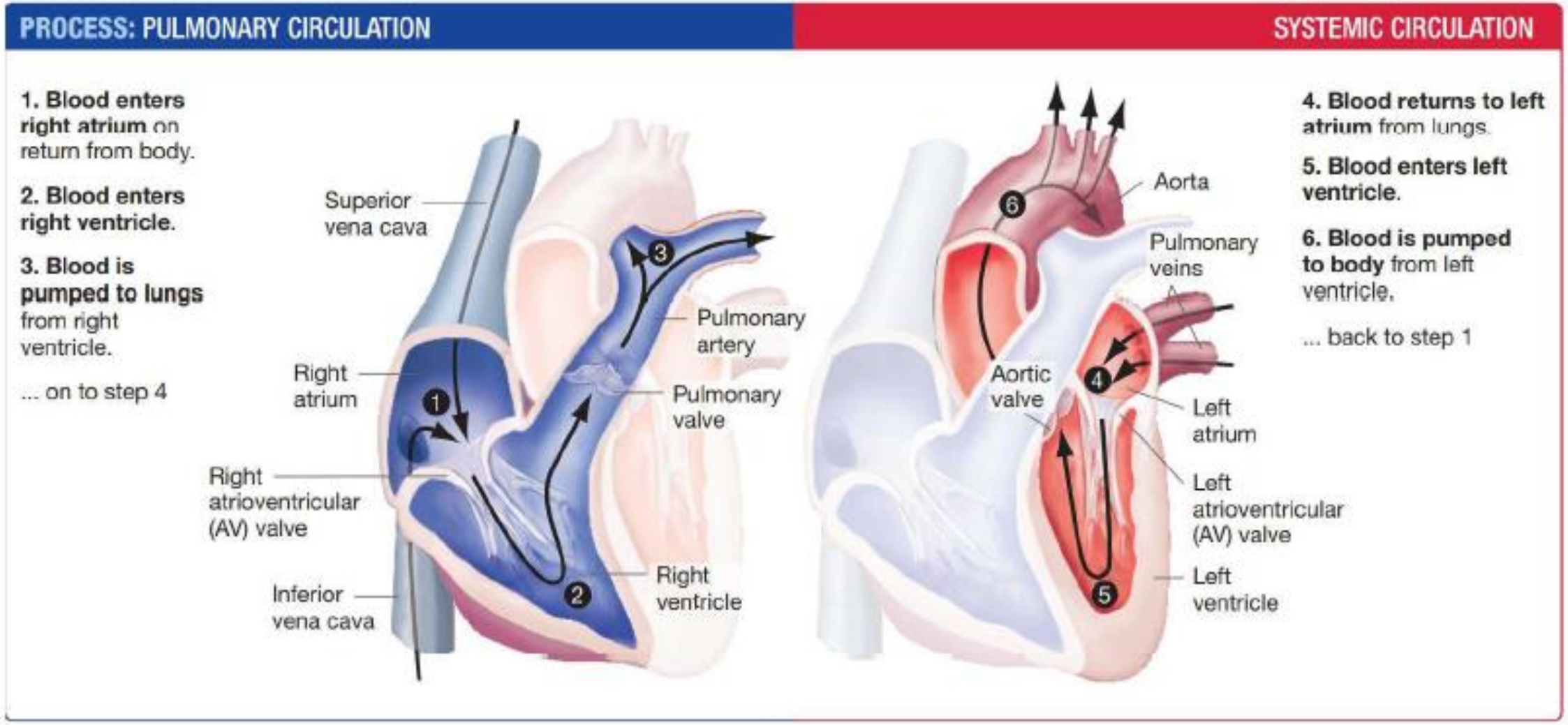


Figure 42.22 The Human Heart Maintains Separation of Highly Oxygenated and Poorly Oxygenated Blood.
Blood flows through the chambers in the sequence shown.

THE CARDIC CYCLE

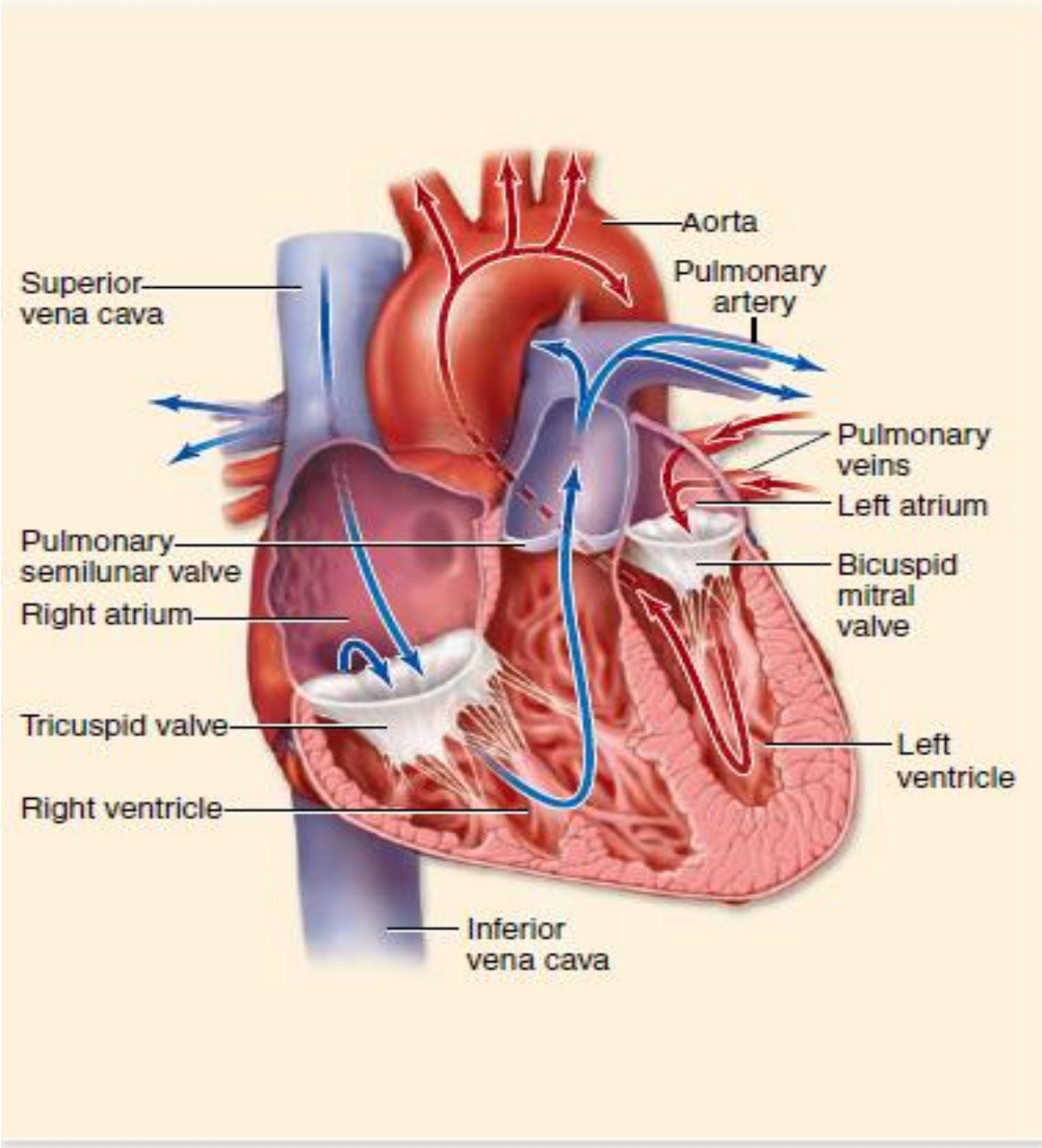
- The cardiac cycle refers to the sequence of events that occur during one complete heartbeat.
- It can be divided into two phases:

1. **diastole** and
2. **systole**.

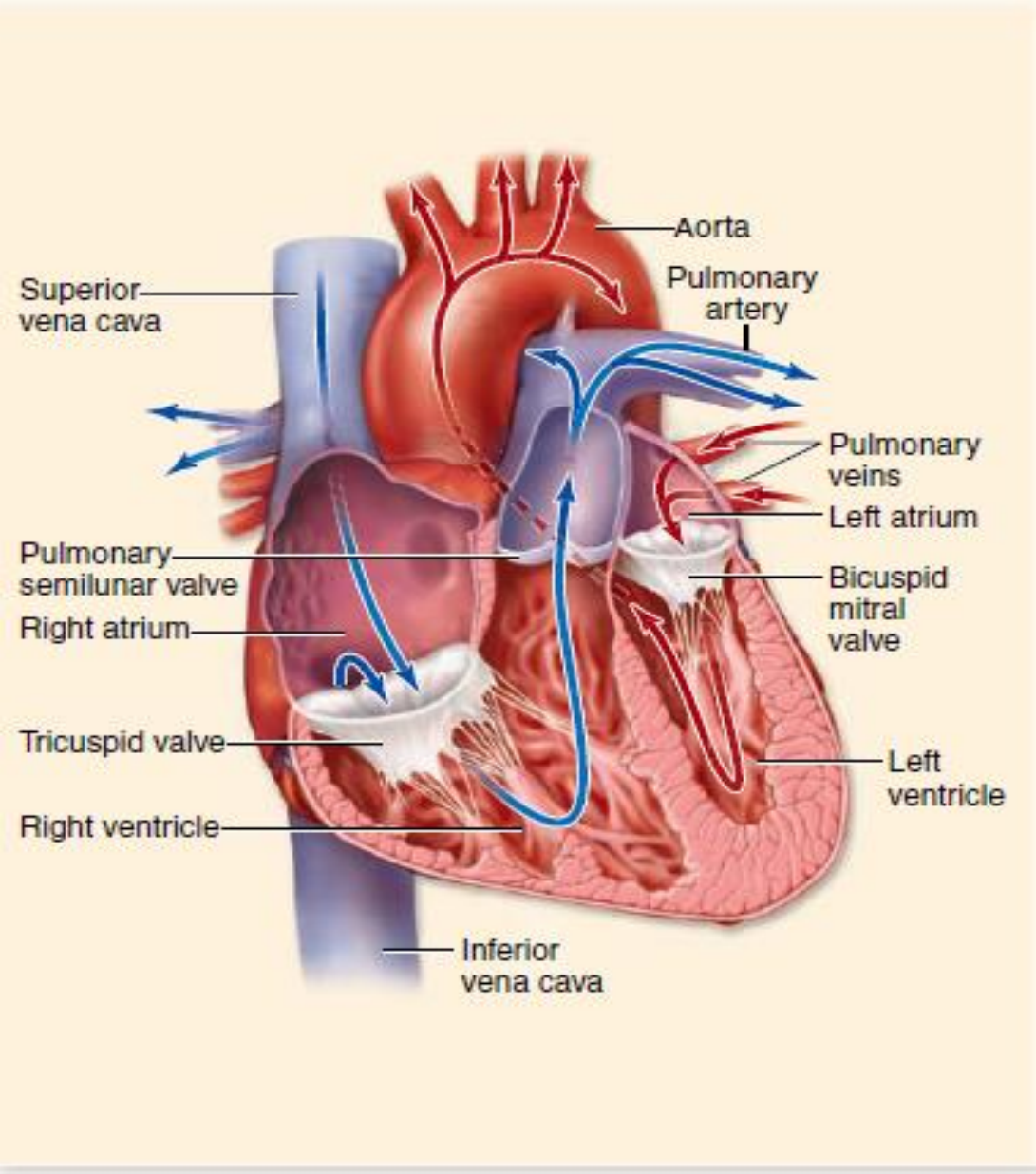
- During diastole, the heart muscle relaxes and fills with blood, while
- During systole, the heart contracts and pumps blood out.

What happens during the cardiac cycle?

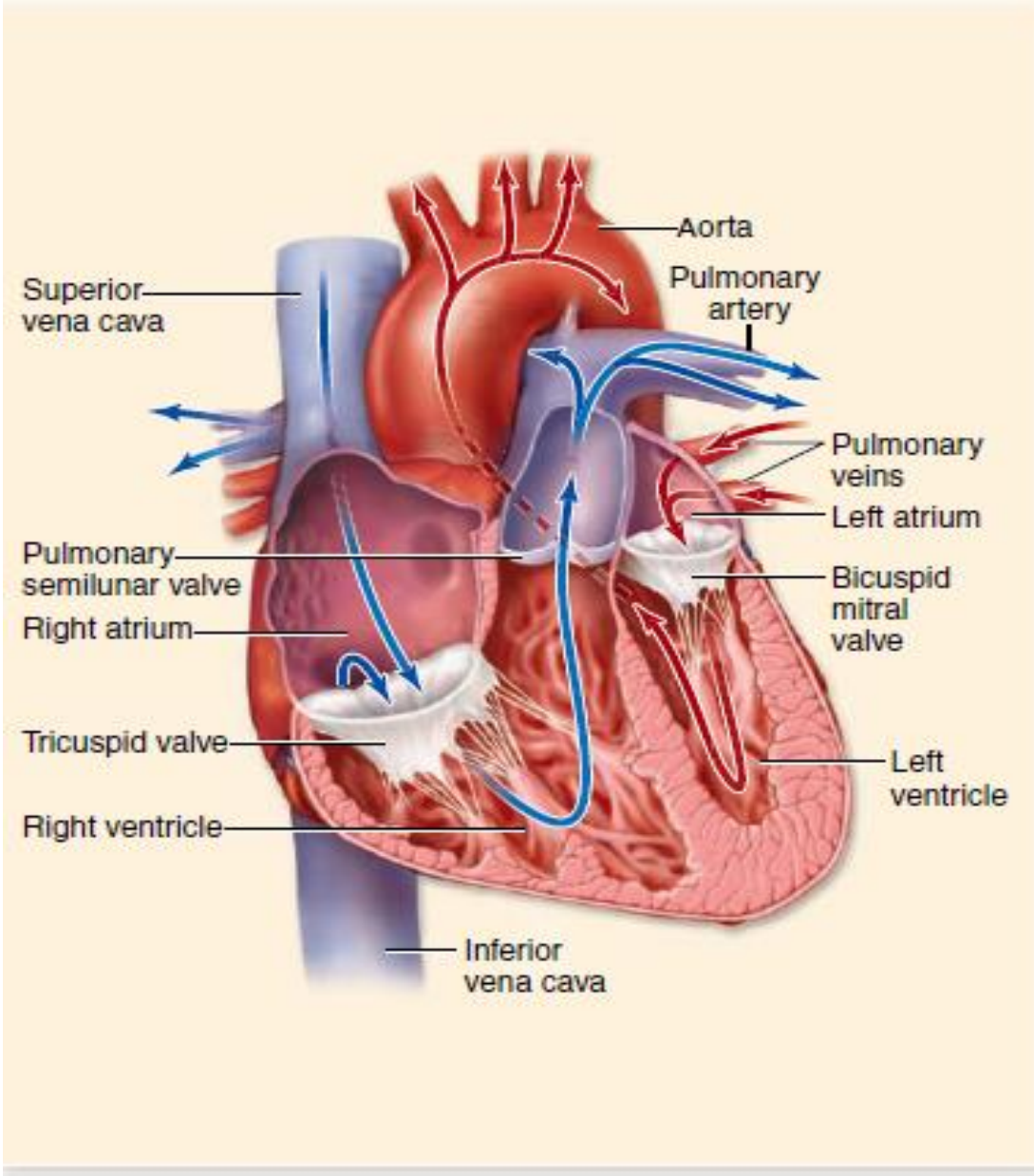
- Blood returns to the resting heart through veins that empty into the right and left atria.
- As the atria fill and the pressure in them rises, the AV valves open to admit the blood into the ventricles.
- The ventricles become about 80% filled during this time.



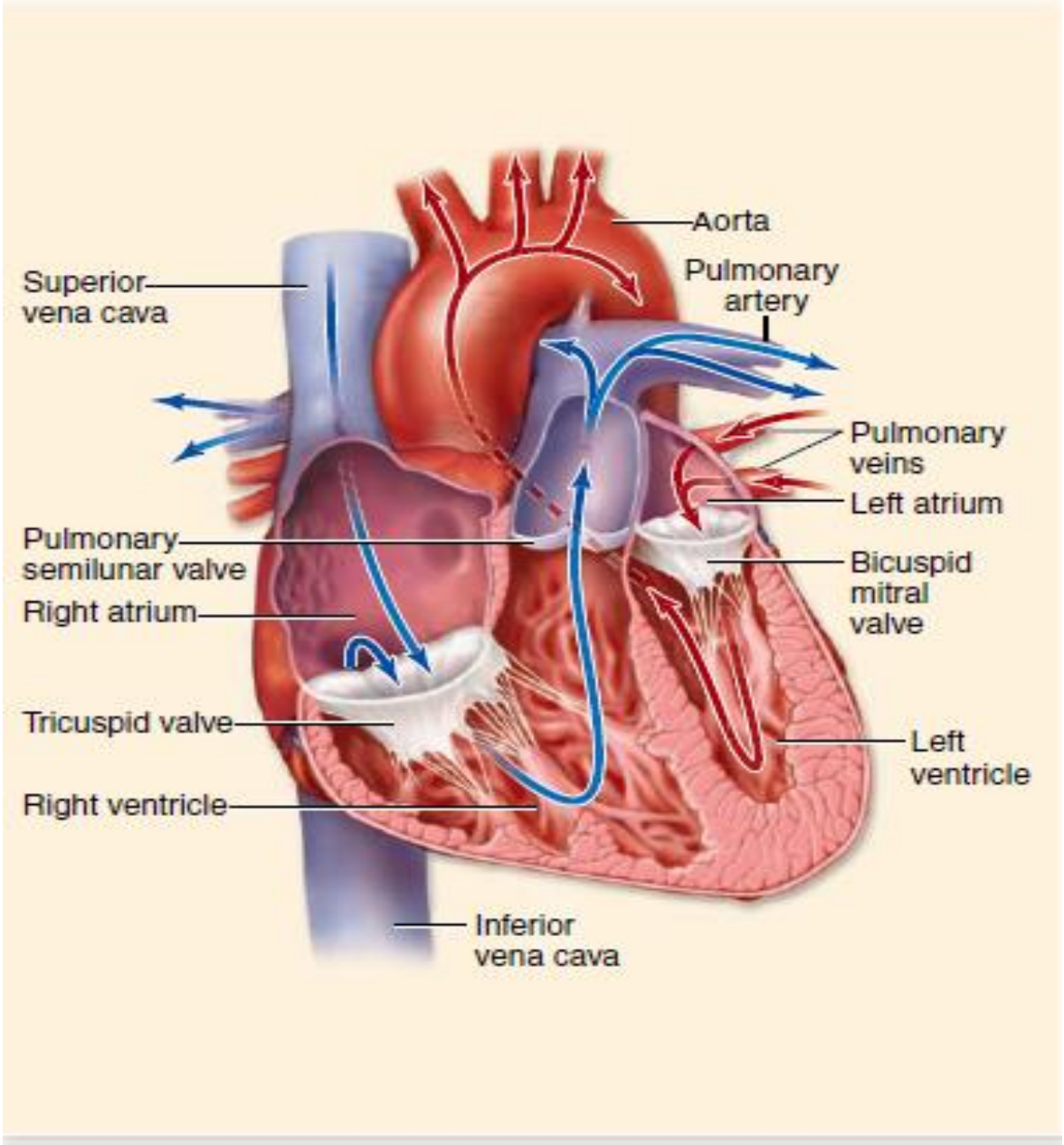
- Contraction of the atria wrings out the final 20% of the 80 milliliters of blood the ventricles will receive, on average, in a resting person.
- These events occur while the ventricles are relaxing, a period called ventricular **diastole.**
- After a slight delay, the ventricles contract; this period of contraction is known as ventricular **systole.**



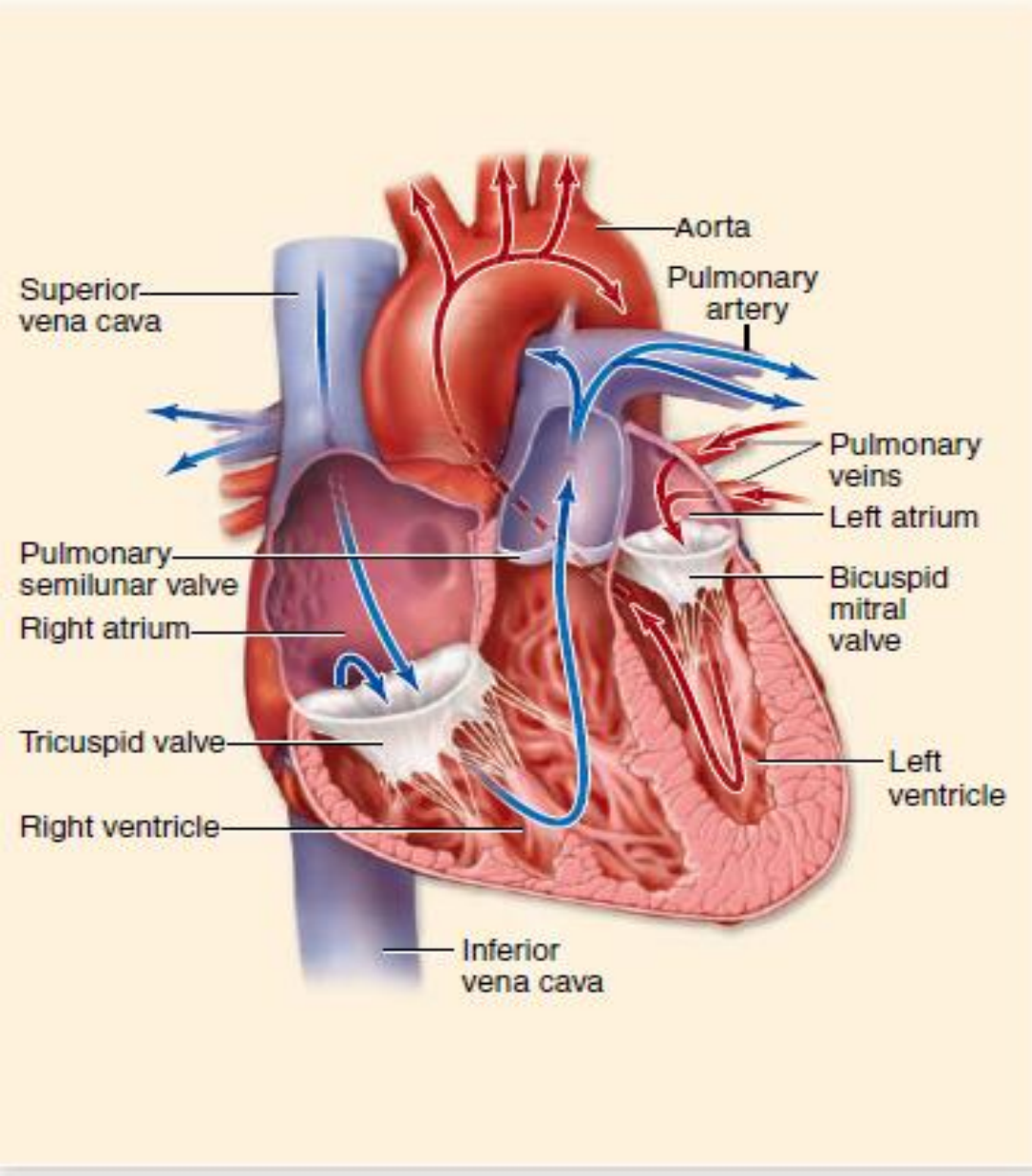
- Contraction of each ventricle increases the pressure within each chamber, causing the AV valves to forcefully close (the “lub” sound), thereby preventing blood from backing up into the atria.
- Immediately after the AV valves close, the pressure in the ventricles forces the semilunar valves open so that blood can be pushed out into the arterial system.
- As the ventricles relax, closing of the semilunar valves prevents back flow (the “dub” sound).



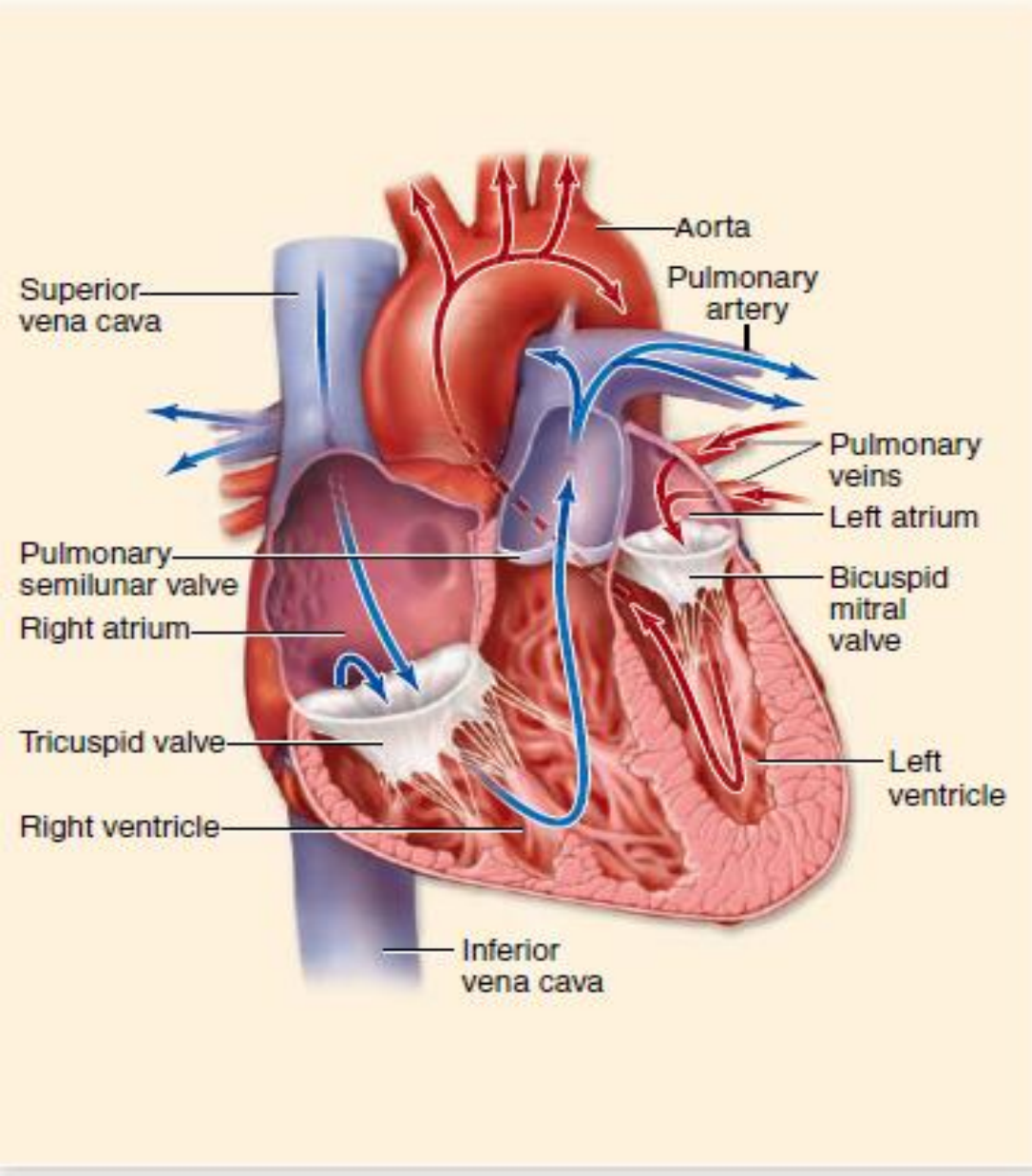
- The right and left **pulmonary arteries** deliver oxygen-depleted blood to the right and left lungs.
- As previously mentioned, these return blood to the left atrium of the heart via the **pulmonary veins.**
- The **aorta** and all its branches are systemic arteries carrying oxygen-rich blood from the left ventricle to all parts of the body.



- The **coronary arteries** are the first branches off the aorta; these supply the heart muscle itself.
- Other systemic arteries branch from the aorta as it makes an arch above the heart, and as it descends and traverses the thoracic and abdominal cavities.
- These branches provide all body organs with oxygenated blood.



- The blood from the body organs, now lower in oxygen, returns to the heart in the systemic veins.
- These eventually empty into two major veins: the **superior vena cava,** which drains the upper body, and the **inferior vena cava,** which drains the lower body.
- These veins empty into the right atrium and thereby complete the systemic circulation.



THE BLOOD VESSELS

❖ blood vessels are closed tubular network responsible for transport of blood from the heart to every part of the body and to bring it back.

❖If all the blood vessels in a human body were laid end to end, they would stretch about 100,000 km (over 60,000 miles).

Types of blood vessels

- Blood vessels are classified as follows:

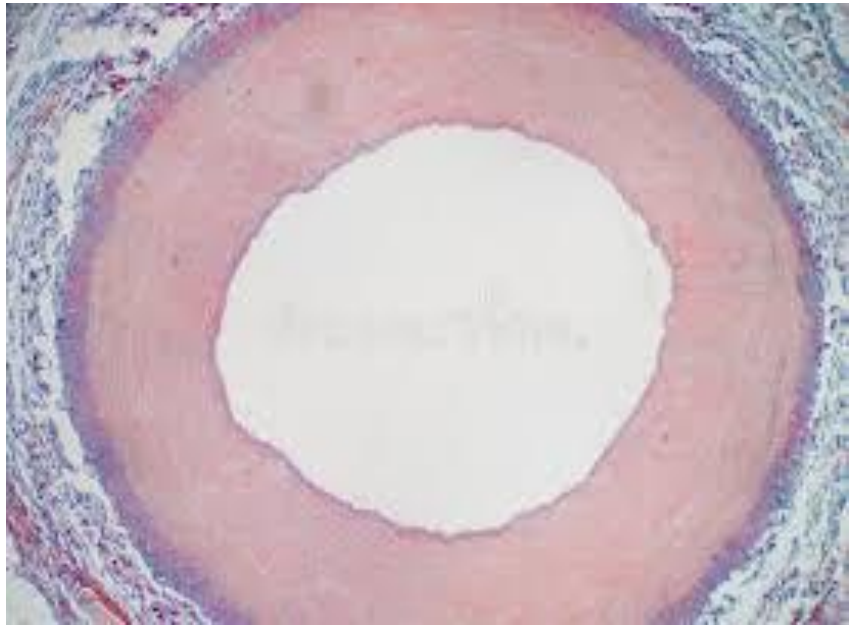
✓ **A**rteries (carry blood **a**way from the heart)

✓ Veins (carry blood to the heart)

✓ Capillaries (joins arteries to veins)

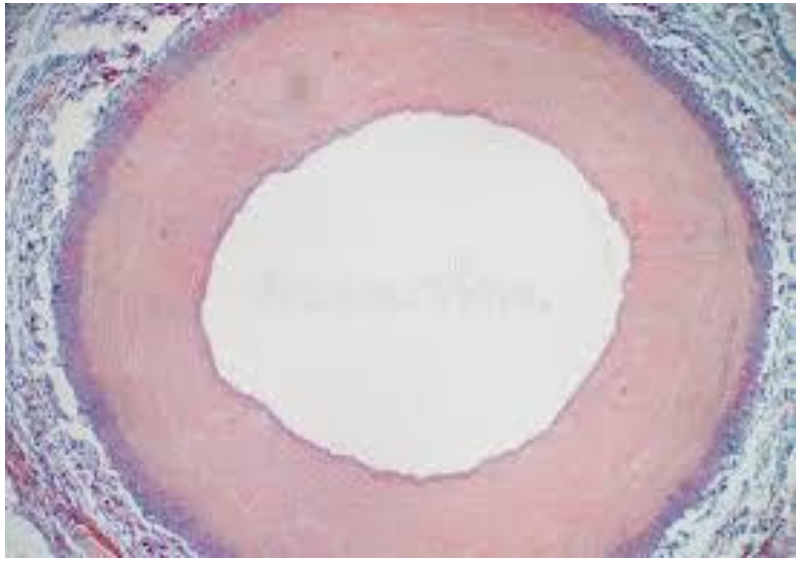
1. Arteries

- Carry blood away from the heart
- Designed to withstand pressure during systole



Characteristics of arteries

- Located deep in the muscle
- Have very thick walls
- Carry blood from the heart to the organs
- Carry oxygenated blood (except for the pulmonary artery)
- Has a thick layer of muscle tissue inside
- Have narrow lumens.
- Have no valves (except for the pulmonary artery)



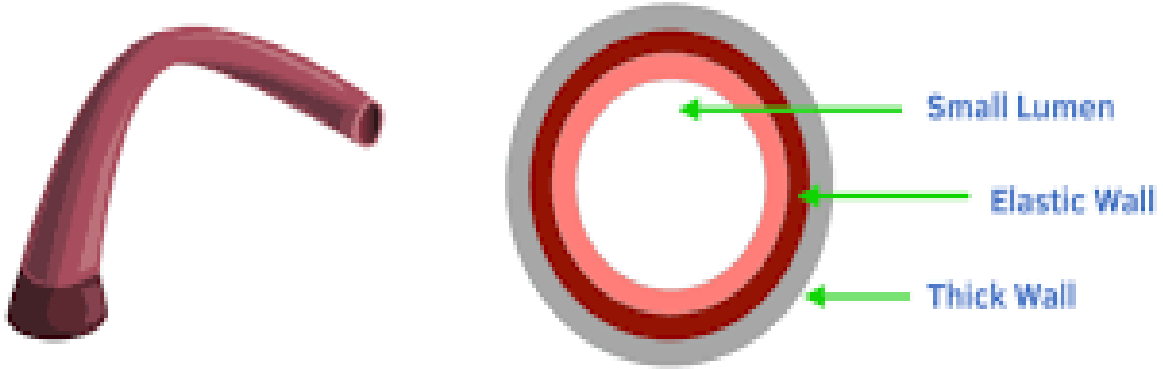


Fig 1. Structure of Arteries.

Adaptations of arteries to their functions

- Arteries have a thick, muscular wall that allows them to withstand the high pressure of blood flow from the heart.
- Arteries, especially the large elastic arteries like the aorta, possess a high degree of elasticity that allows them to expand and accommodate the volume of blood pumped out by the heart during systole (contraction).
- The smooth muscle cells in the arterial walls can contract (vasoconstriction) or relax (vasodilation) in response to various stimuli which allows them to adjust the diameter of the arteries allows for the regulation of blood flow and pressure to different body tissues.
- They posses narrower lumens to maintain blood flow at a high to reach far parts of the body.

2. Veins

- Veins carry deoxygenated blood towards your heart and are often located close to your skin.
- Veins don’t have a muscular layer like arteries do, so they rely on valves to keep your blood moving.
- Veins start as tiny blood vessels called venules, which become full-size veins as they come closer to your heart.

Characteristics of Veins.

- ✓ Are located closer to the surface of your body.
- ✓ Have thin walls.
- ✓ Carry blood towards your heart.
- ✓ Carry deoxygenated blood (except the pulmonary vein)
- ✓ Have wider lumens.
- ✓ Has a thin layer of muscle tissue inside.
- ✓ Contain valves to keep blood flowing.

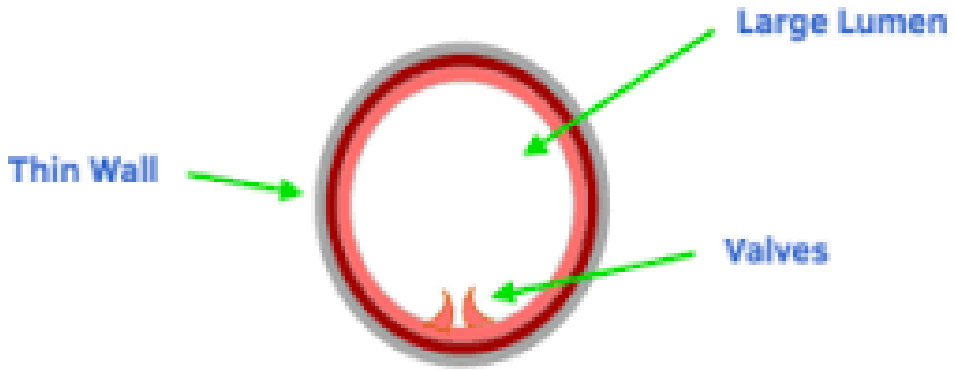


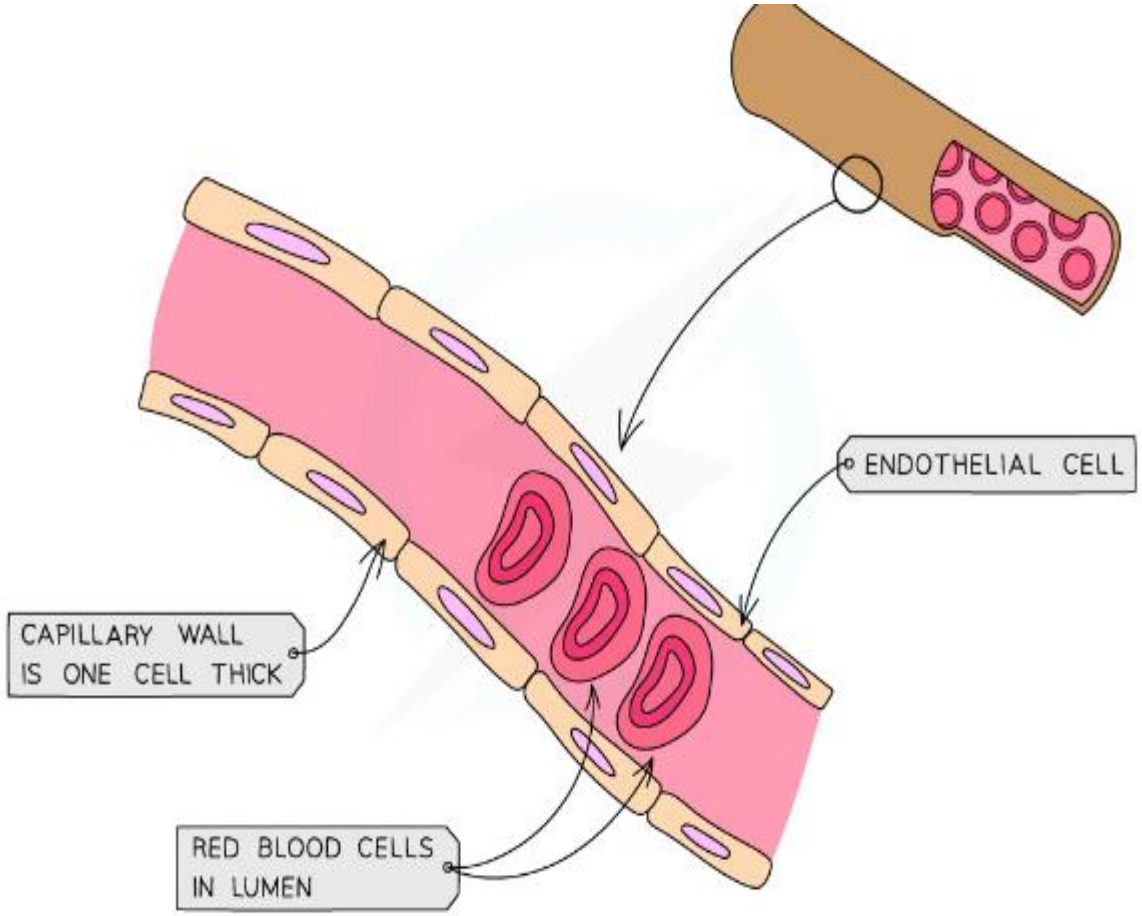
Fig 1. Vein.

Adaptations of veins to their function

- The elastic layer is relatively thin because blood is under low pressure, cant cause them to burst and the pressure is too low to create a recoil action
- The muscular wall is relatively thin because veins carry blood away from tissues and therefore their dilation and constriction cannot control the flow of blood to the tissues
- The collagen fibres provide a tough outer layer in order to prevent the veins bursting from the external forces
- There are semilunar valves throughout to ensure that blood does not flow backwards, which it might otherwise do because the pressure is so low.
- The overall thickness of the wall is small because there's no need for a thick wall as the pressure within the veins is too low to create any risk of bursting.

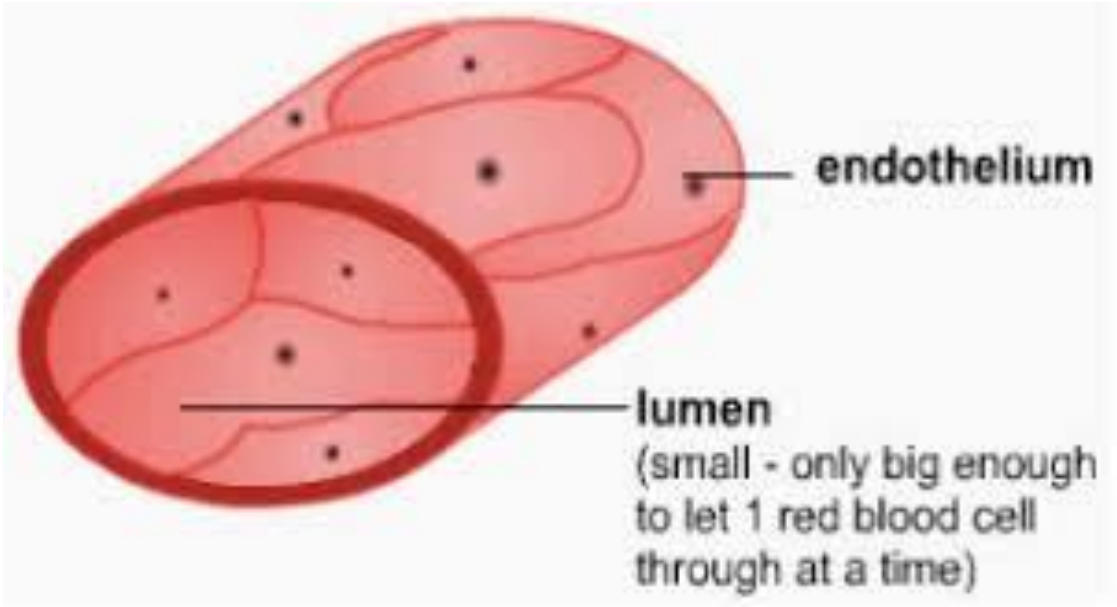
3. Capillaries

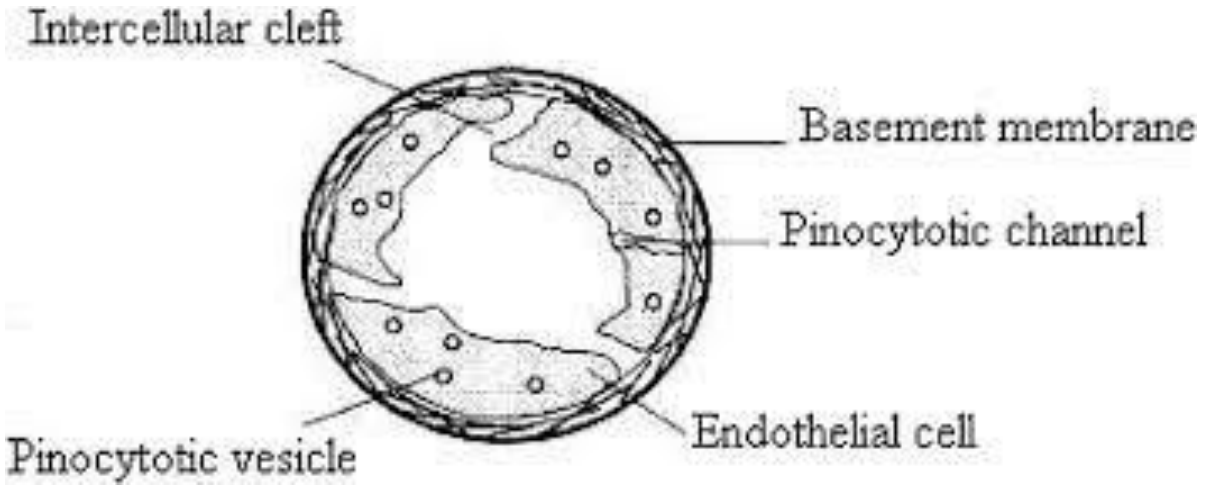
- ❖ Capillaries connect your arteries to your veins.
- ❖ Capillaries are the smallest type of blood vessel.
- ❖They can be as tiny as 5 micrometers, which is less than a third of a hair's width.
- ❖ A capillary wall is only one cell in thickness.
- ❖The capillary wall is made of endothelial cells and allows oxygen, nutrients, and waste to pass to and from tissue cells.



Characteristics of Capillaries.

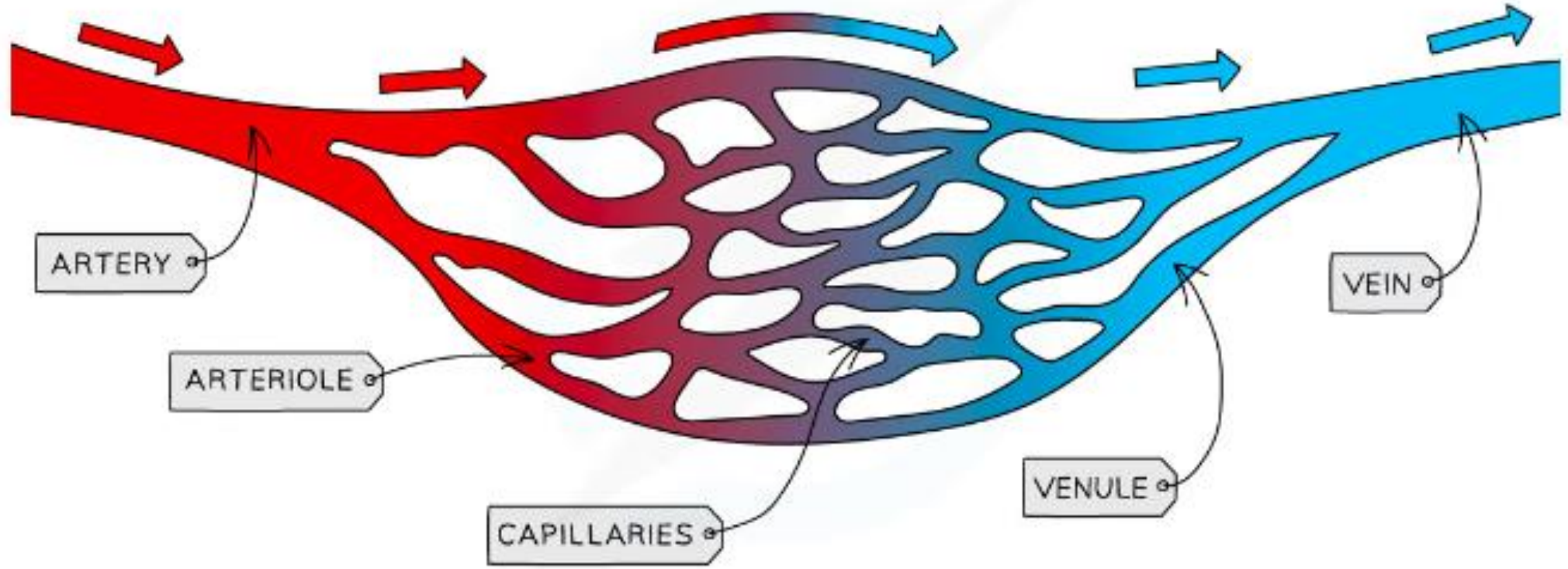
- Are located inside all tissues
- Have a very thin wall
- Carry blood between veins and arteries
- Carry both oxygenated and deoxygenated blood
- Don't have muscle tissue
- Don't have valves

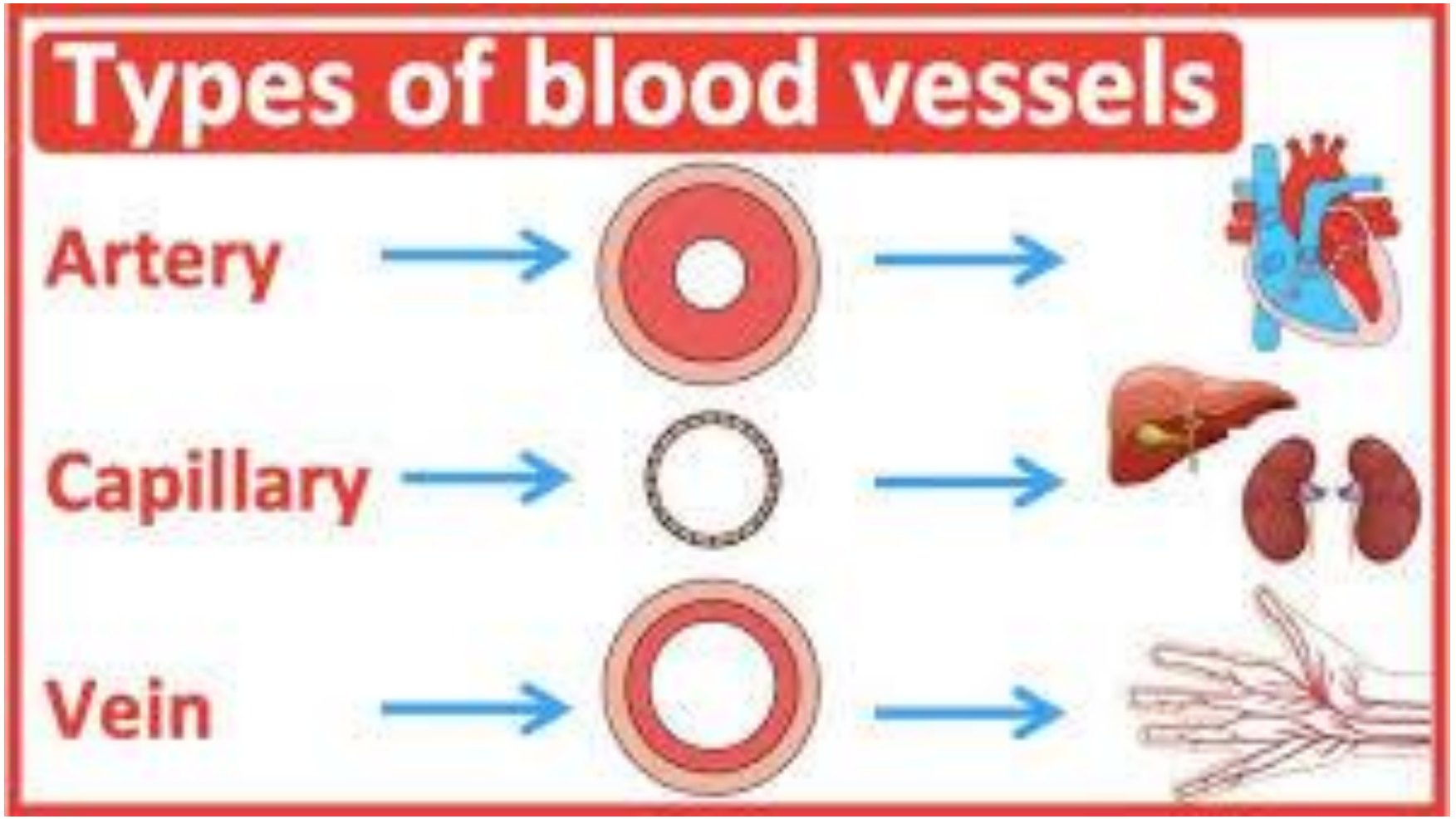




Adaptations of blood capillaries

1. They possess the capillary sphincter muscles which contract and relax so as to regulate the amount of blood entering into the capillary network.
2. Capillaries have walls that are **one cell thick** (short diffusion distance) so substances **can easily diffuse** in and out of them
3. The ‘leaky’ walls **allow blood plasma to leak out and form tissue fluid** surrounding cells
4. They **are numerous in number to provide a large surface area** which increases the rate of diffusion and allows rapid exchange of materials between blood and the tissue fluid.


ARTERY
ARTERIOLE
CAPILLARIES
VENULE
VEIN

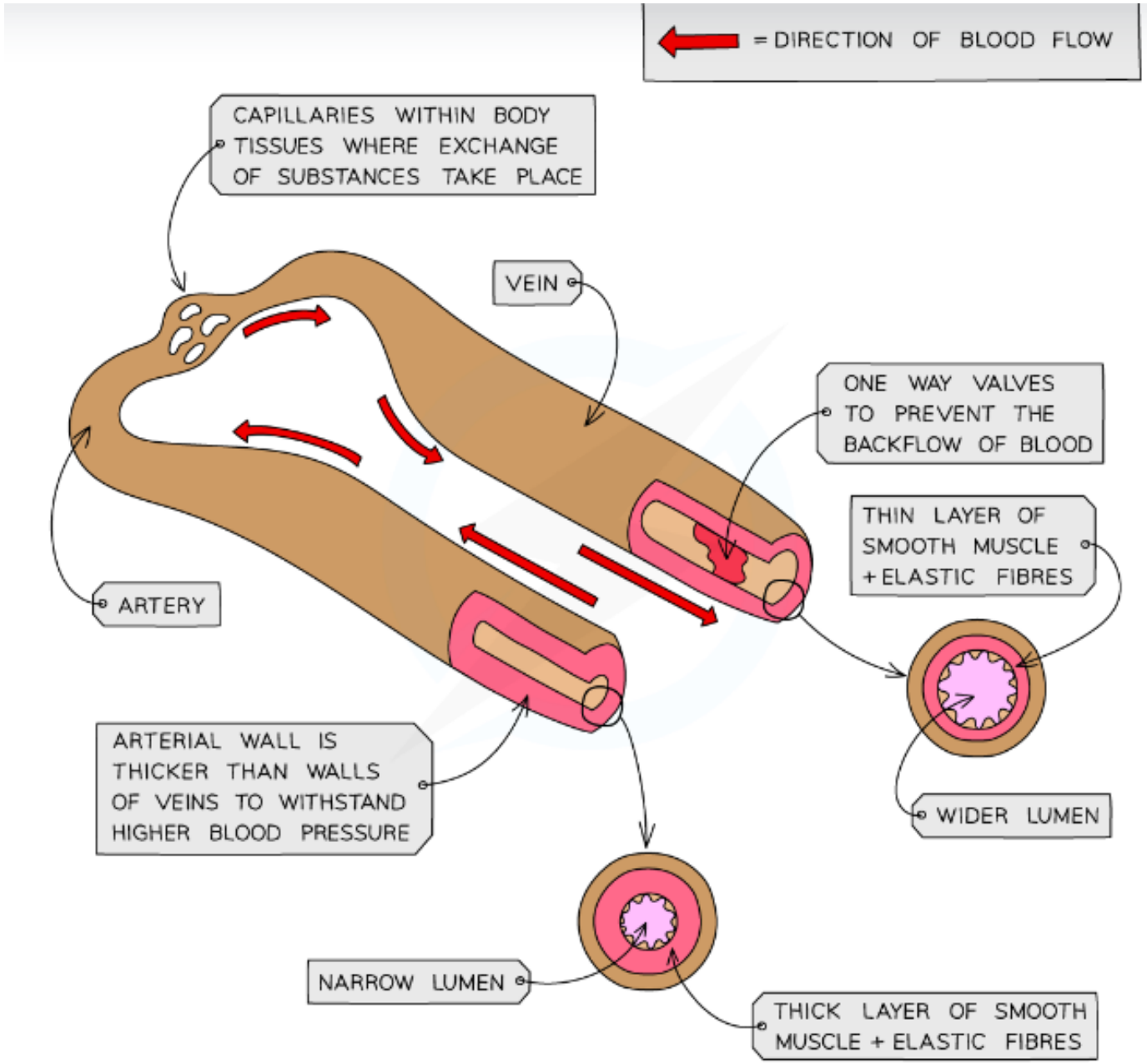

Types of blood vessels
Artery
Capillary
Vein

Assignment

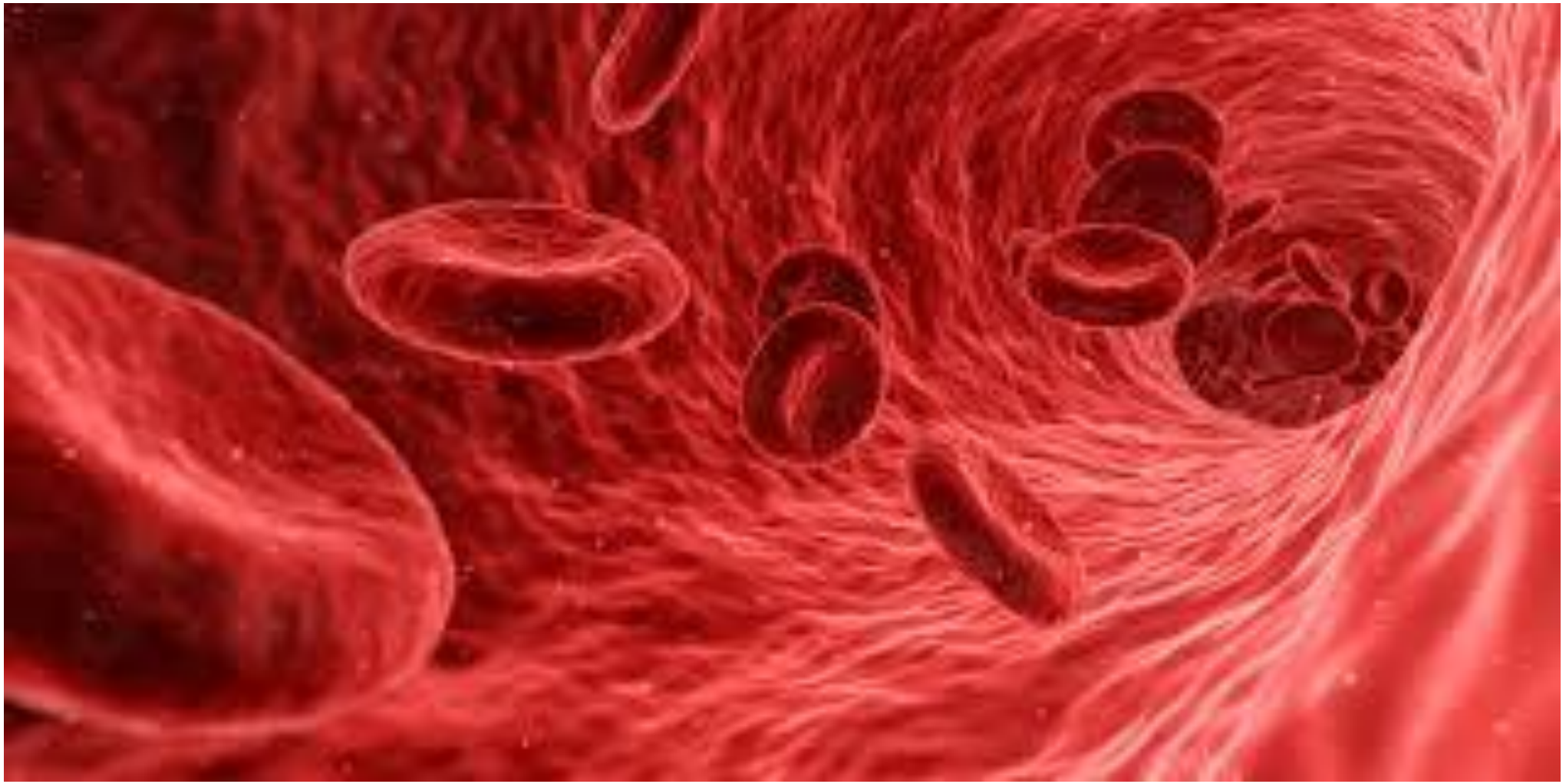
Using different reading materials such as text books and internet,

Compare (differences and similarities)

1. arteries and veins
2. Arteries and capillaries
3. Veins and capillaries


= DIRECTION OF BLOOD FLOW
CAPILLARIES WITHIN BODY TISSUES WHERE EXCHANGE OF SUBSTANCES TAKE PLACE
VEIN
ONE WAY VALVES TO PREVENT THE BACKFLOW OF BLOOD
THIN LAYER OF SMOOTH MUSCLE + ELASTIC FIBRES
ARTERY
ARTERIAL WALL IS THICKER THAN WALLS OF VEINS TO WITHSTAND HIGHER BLOOD PRESSURE
WIDER LUMEN
NARROW LUMEN
THICK LAYER OF SMOOTH MUSCLE + ELASTIC FIBRES

BLOOD



- Blood consists of red cells, white cells and platelets floating in a liquid called plasma.
- There are between 5 and 6 litres of blood in the body of an adult, and each cubic centimetre contains about 5 billion red cells.

Functions of blood

Blood carries out several function in the body which include the following.

- **Transport of oxygen and carbon dioxide.** Red blood cells carry oxygen from the lungs to the body's tissues and removes carbon dioxide, a waste product of cellular respiration, from the tissues to be exhaled by the lungs.
- **Transports of digested food nutrient.** Blood also carries nutrients such as glucose, amino acids, and fatty acids from the digestive system to the body's cells for energy and growth.
- **Transport of hormones**. Blood transports hormones in the plasma, which are chemical messengers that regulate various body functions.
- **Thermo regulation.** Blood also helps regulate body temperature by absorbing and redistributing heat.
- **Provides immunity to the body.** Blood plays a crucial role in the body's defense against infections by carrying white blood cells that help fight pathogens and by transporting antibodies, which are proteins that target and neutralize specific pathogens.

The components of blood and their functions

Red blood cells

- These are tiny, disc-like cells to easily pass through the narrow blood vessels.
- Lack nuclei to offer more space for oxygen loading .
- They are made of spongy cytoplasm enclosed in an elastic cell membrane to enable then squeeze through the narrow blood vessels.
- In their cytoplasm is the red pigment haemoglobin, a protein combined with iron which combine with oxygen.
- Red cells are made by the red bone marrow of certain bones

Red blood cells transport respiratory gases

White blood cells (leukocytes)

- They have a nucleus even at maturity to enable them carry out complex activities.
- They are relatively few in blood but their number increases when the body is attached by an infection
- White blood cells are divided into two major categories. These are;

1. **Phagocytes**. These are white blood cells with a lobed nucleus. They ingest and destroy germs by phagocytes.

- They have no definite shape (they are amoeboid) allowing them to squeeze through blood vessel walls and move towards infection sites

2. **Lymphocytes**. These are white blood cells, which defend the body by producing antibodies.

White blood cells are involved with phagocytosis and antibody production for body defense

- **Plateletes (**thrombocytes**)**

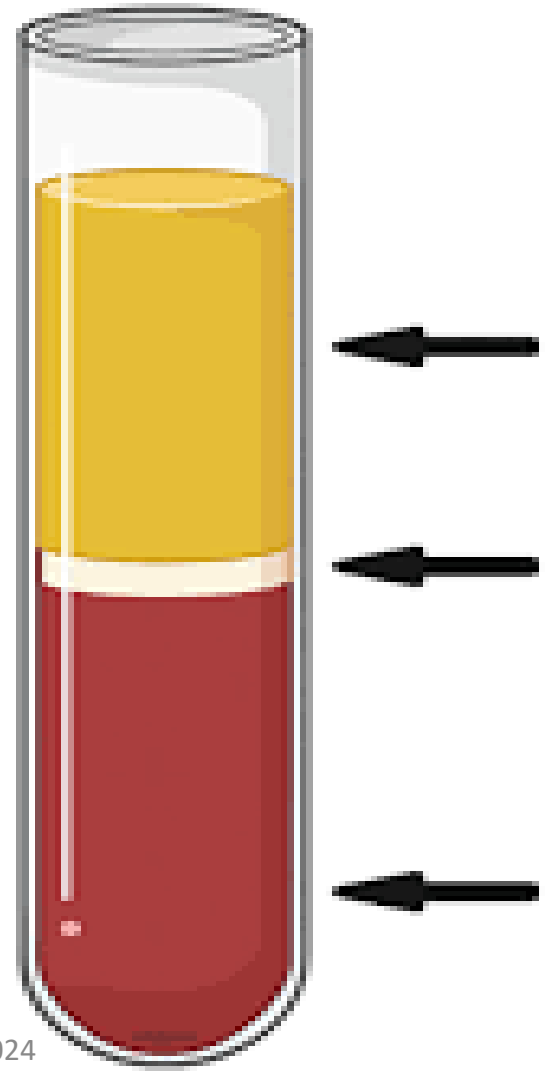
➢ Are small, colorless cell fragments found in the blood.

➢ Platelets have a sticky surface that allows them to stick to the walls of blood vessels when there is an injury. This helps them form a clot and prevent more blood from flowing out.

➢ Platelets have special parts inside them called granules. These granules contain helpful substances that are released when platelets are activated. These substances help heal the injury and make the blood clot stronger.

➢ They play a crucial role in the process of blood clotting, which is essential for stopping bleeding and promoting wound healing

Blood plasma



Plasma
(55% of total blood)

Buffy Coat
leukocytes & platelets
(<1% of total blood)

Erythrocytes
(45% of total blood)

- It is the liquid part of the blood.
- It is water with a large number of substances dissolved in it.
- The ions of sodium, potassium, calcium, chloride, hydrogen carbonate, are present.
- Proteins such as fibrinogen, albumin and globulins make up an important part of the plasma. Fibrinogen is needed for clotting and the globulin proteins include antibodies, which combat bacteria and other foreign matter.
- The plasma will also contain varying amounts of food substances such as amino acids, glucose and lipids (fats).
- There may also be hormones present, depending on the activities taking place in the body.
- The excretory product, urea, is dissolved in the plasma, along with carbon dioxide.
- The liver and kidneys keep the composition of the plasma more or less constant, but the amount of digested food, salts and water will vary within narrow limits according to food intake and body activities.

Roles of blood plasma

- Plasma transports blood cells, ions, soluble nutrients, e.g. glucose, hormones and carbon dioxide.
- To transport food nutrients from the gut to the other parts of the body.
- To transport hormones from gland producing them to the target sites.
- To transport antibodies to the infected parts of the body.
- To transport Urea from the liver to the Kidneys for excretion.
- To transport carbon dioxide from the body muscles to gaseous exchange system.
- To transport heat from the liver and body muscles to other body parts hence maintaining a constant body temperature range.
- To transport platelets to injured sites on the body so as to initiate blood clotting.
- To distribute salts around the body so as to maintain the body's electrolytes balance.

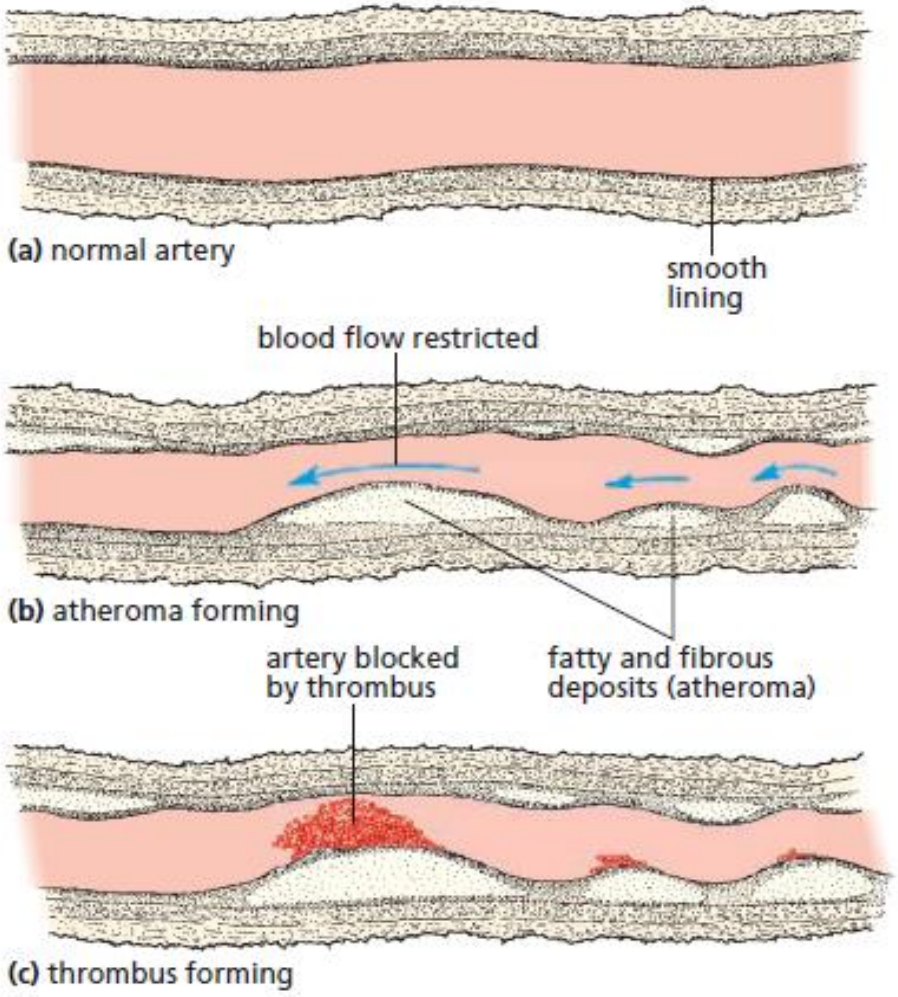
Diseases and disorders of the circulatory system

- Failure of circulatory system to function properly leads to circulatory disorders including heart diseases
- There are different types of circulatory disorders and heart diseases, such as coronary artery disease, high blood pressure, stroke, arrhythmias, and valvular heart disease.

Some of the key circulatory disorders and heart diseases

1. Coronary heart disease

- In the lining of the large and medium arteries, deposits of a fatty substance, called atheroma, are laid down in patches.
- This happens to everyone and the patches get more numerous and extensive with age, but until one of them actually blocks an important artery the effects are not noticed.
- The patches may join up to form a continuous layer, which reduces the internal diameter of the vessel



- The surface of a patch of atheroma sometimes becomes rough and causes fibrinogen in the plasma to deposit fibrin on it, causing a blood clot (a **thrombus**) to form.
- If the blood clot blocks the coronary artery which supplies the muscles of the ventricles with blood, it starves the muscles of oxygenated blood and the heart may stop beating. This is a severe heart attack from **coronary thrombosis**.
- A thrombus might form anywhere in the arterial system, but its effects in the coronary artery and in parts of the brain (strokes) are the most drastic.
- In the early stages of coronary heart disease, the atheroma may partially block the coronary artery and reduce the blood supply to the heart This can lead to **angina**, i.e. a pain in the chest that occurs during exercise or exertion.
- This is a warning to the person that he or she is at risk and should take precautions to avoid a heart attack.

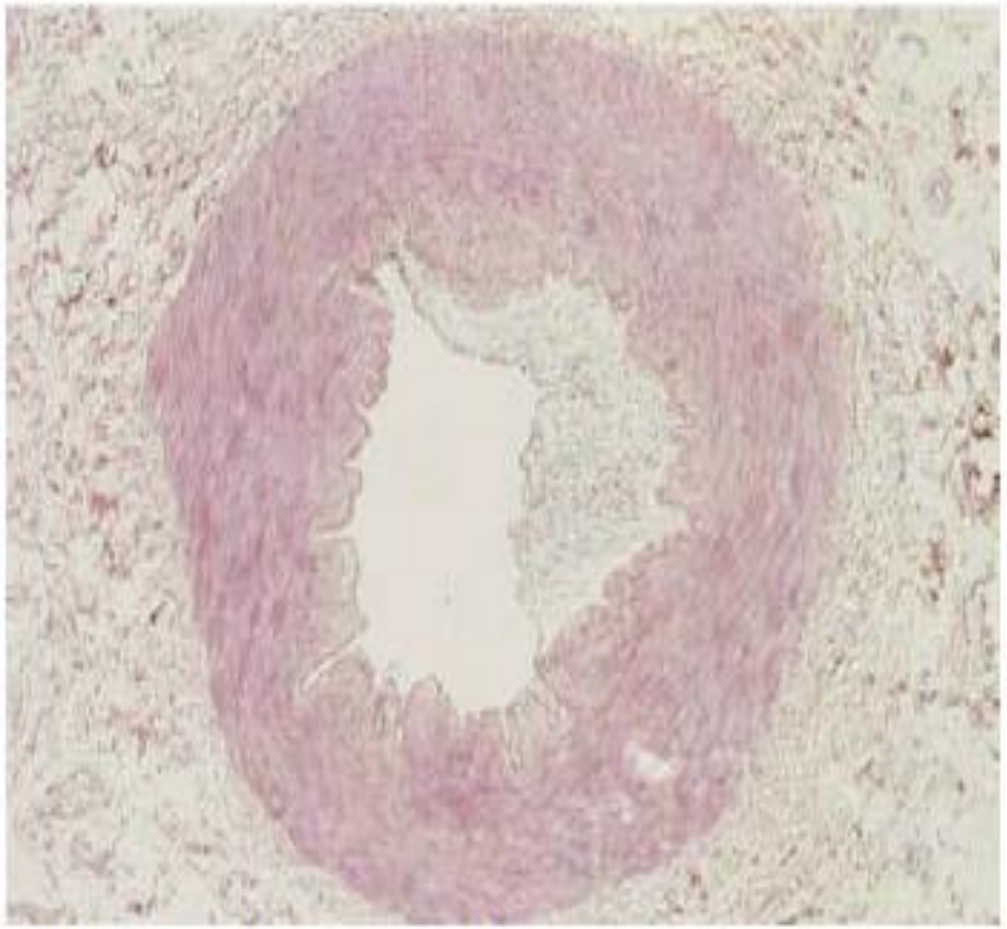


Figure 9.11 Atheroma partially blocking the coronary artery

2. High blood pressure

- Sometimes fats accumulate in the blood vessels making their rumens narrow. This increases blood pressure and it is the major cause of high blood pressure in fat people, however small people also experience high blood pressure. This is due to conditions like stress, anxiety, fear, etc.
- These conditions tend to increase the rate of heartbeat and more blood is pumped to the blood vessels causing high pressure in them.
- Although blood pressure varies with age and activity, it is normally kept within specific limits by negative feedback.
- The filtration process in the kidneys needs a fairly consistent blood pressure. If blood pressure falls significantly because, for example, of loss of blood or shock, then the kidneys may fail.
- Blood pressure consistently higher than normal increases the risk of heart disease or stroke

3. Stroke

- A stroke is a medical condition that occurs when the blood supply to the brain is disrupted, leading to damage to brain cells.
- This disruption can be caused by a blockage in a blood vessel or bleeding into the brain

CAUSES OF HEART DISEASES

Stress. Emotional stress often leads to raised blood pressure. High blood pressure may increase the rate at which atheroma are formed in the arteries

Smoking. Smokers are two to three times more likely to die from a heart attack than are non-smokers of a similar age The carbon monoxide and other chemicals in cigarette smoke may damage the lining of the arteries, allowing atheroma to form.

Fatty diets. The atheroma deposits contain **cholesterol**, which is present, combined with lipids and proteins, in the blood.

- It is known that people with high levels of blood cholesterol are more likely to suffer from heart attacks than people with low cholesterol levels stress
- Blood cholesterol can be influenced, to some extent, by the amount and type of fat in the diet.
- Many doctors and dieticians believe that animal fats (milk, cream, butter, cheese, egg-yolk, fatty meat) are more likely to raise the blood cholesterol than are the vegetable oils, which contain a high proportion of unsaturated fatty acids
- An unbalanced diet with too many calories can lead to obesity. Being overweight puts extra strain on the heart and makes it more difficult for the person to exercise.

Age

As we get older our risk of suffering from coronary heart disease increases.

Gender

Males are more at risk of a heart attack than females: it may be that males tend to have less healthy lifestyles than females.

Lack of exercise

Heart muscle loses its tone and becomes less efficient at pumping blood when exercise is not untaken. A sluggish blood flow, resulting from lack of exercise, may allow atheroma to form in the arterial lining.

Genetic predisposition

Coronary heart disease appears to be passed from one generation to the next in some families. This is not something we have any control over, but we can be aware of this risk and reduce some of the other risk factors to compensate.

Causes of Heart Disease

PREVENTION OF HEART DISEASES AND OTHER CIRCULATORY DISEASES

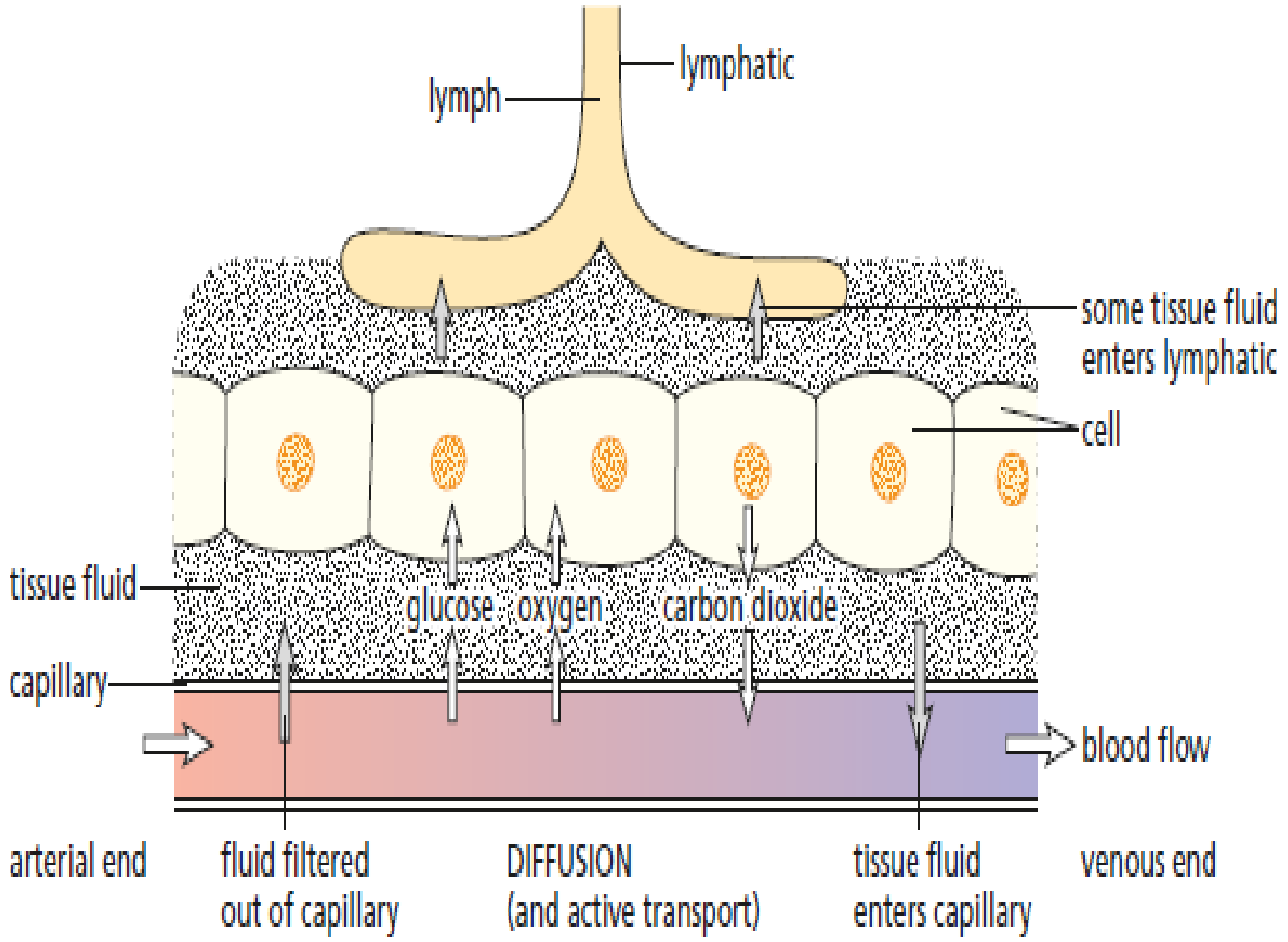
- **Maintain a healthy diet**. Include a variety of fruits, vegetables, whole grains, lean proteins, and healthy fats in your diet. Limit your intake of saturated and trans fats, cholesterol, sodium, and added sugars.
- **Engage in regular physical activity.** Aim for at least 150 minutes of moderate-intensity aerobic exercise or 75 minutes of vigorous-intensity aerobic exercise every week. Additionally, incorporate strength training exercises at least twice a week.
- **Maintain a healthy weight**. Strive to achieve and maintain a healthy body mass index (BMI), as excess weight can increase the risk of heart diseases. Balance your caloric intake with physical activity.
- **Avoid smoking and tobacco products.** Smoking and exposure to secondhand smoke can significantly increase the risk of heart diseases. Quitting smoking and avoiding tobacco products altogether can greatly reduce this risk.

- **Limit alcohol consumption.** Excessive alcohol consumption can contribute to high blood pressure, obesity, and increased cholesterol levels, which are all risk factors for heart diseases. If you choose to drink alcohol, do so in moderation.
- **Manage stress**. Chronic stress can contribute to the development of heart diseases. Implement stress management techniques such as exercise, relaxation techniques, and hobbies to help reduce stress levels.
- **Control blood pressure and cholesterol levels**. Regularly monitor your blood pressure and cholesterol levels, and take necessary steps to keep them within a healthy range. This may include lifestyle modifications or medication, as advised by a healthcare professional.
- **Get regular check-ups**. Visit your healthcare provider regularly for routine check-ups, screenings, and assessments of your overall health. This can help identify any potential risk factors or early signs of heart diseases.

CAPILLARY EXCHANGE, FORMATION OF TISSUE FLUID AND LATER LYMPH.

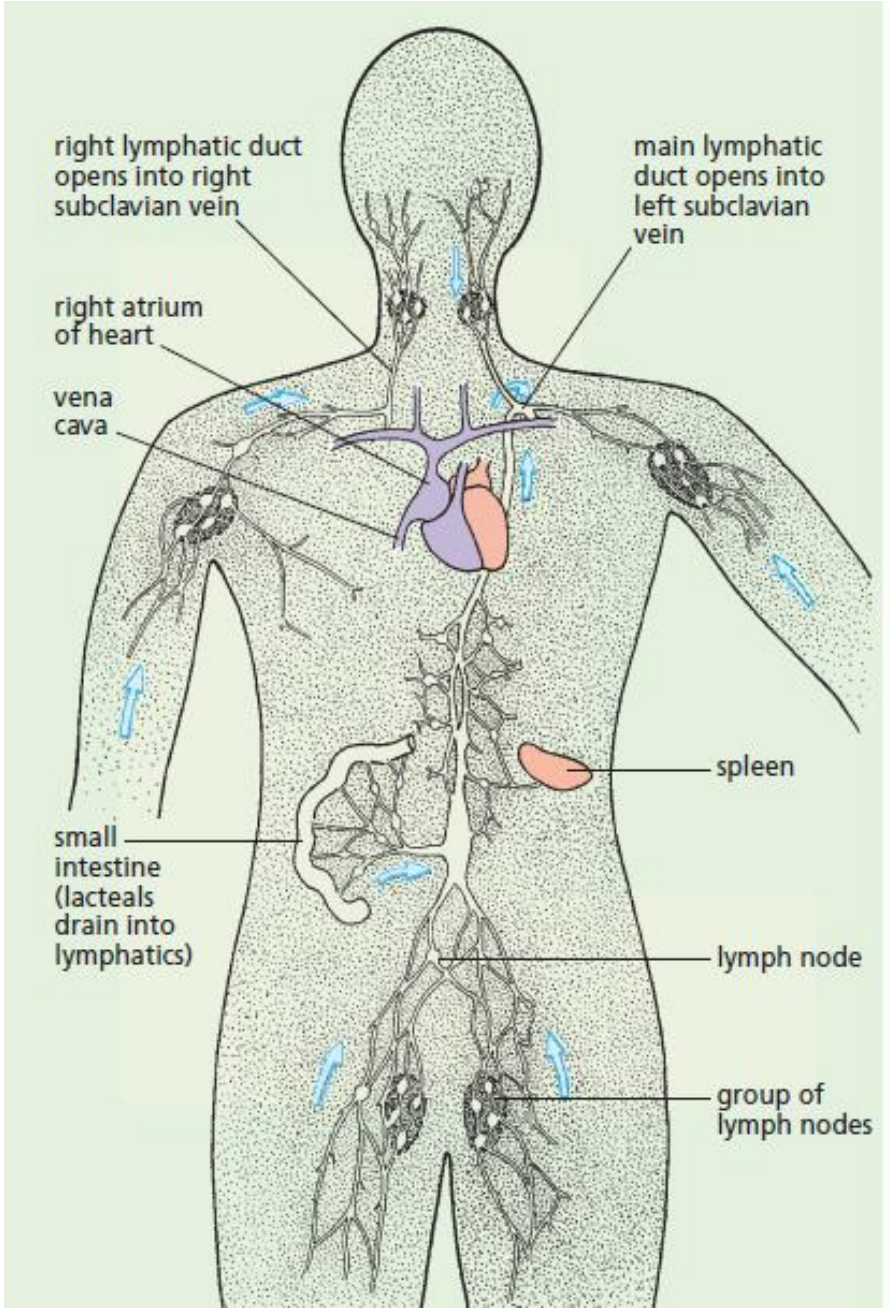
- As blood flows from arterioles into blood capillaries.
- Pressure builds up in the capillaries forcing small molecules like food materials and the fluid part of blood to leave the capillaries and enter the intercellular spaces, leaving behind large molecules like proteins in plasma and cells.
- Once the fluid is in the intercellular spaces of tissues, it is no longer called blood but tissue fluid.
- Once formed, the tissue fluid surrounds the cells. Body cells then get their requirements e.g. glucose, oxygen, etc. from the tissue fluid and they add excretory materials to the fluid

- Some of the fluid returns in to the capillaries and the other is drained in to a system of narrow channels called lymph vessels.
- The fluid in these vessels is now called lymph. Lymph is therefore, tissue fluid in the lymph vessels.



THE LYMPHATIC SYSTEM

- This is part of the vascular system. It forms the second type of circulation.
- Most of the tissue fluid as explained above goes back into the blood capillaries and the remainder enters the lymphatic system and becomes lymph fluid.
- The lymph fluid is transported through lymph vessels.
- The lymph vessels are similar to veins but they have more valves than the veins.
- The movement of the lymph fluid through the lymph vessels is due to the contractions of the surrounding muscles.



- As they contract and relax, they squeeze the lymph vessels to gain the force by which lymph moves. The walls of the lymphatic vessels have pores, which allow the entry of cell, wastes and bacteria.
- Before reaching the blood, lymph passes through the lymph nodes where the wastes and bacteria are removed.
- The lymph joins the blood circulation via the thoracic ducts, which join the vein in the neck. The right thoracic duct drains its contents of the right side and that of the left drains the left side. The lacteals of the ileum are also connected to the left thoracic duct

Functions of the lymphatic system

1. It transports fatty acids and glycerol from the ileum to the heart where they join the blood system.
2. It carries excretory substances from tissues to the blood stream.
3. It produces white blood cells, which assist in defense of the body.
4. It filters out bacteria before they reach the blood stream.
5. Transports hormones from glands to other body parts.

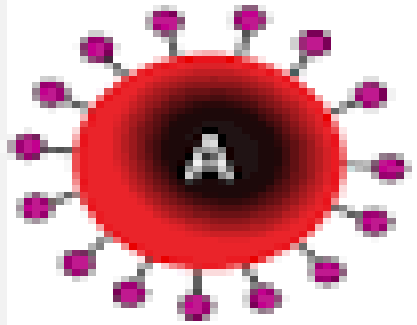
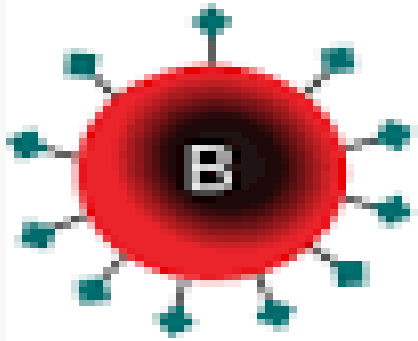
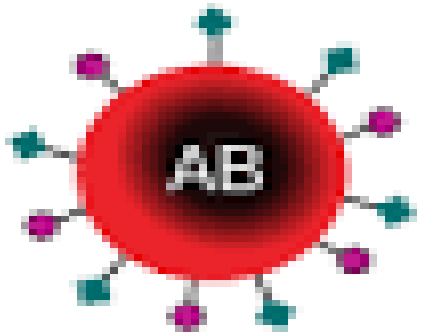
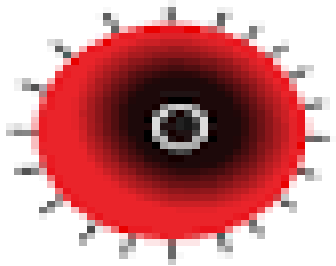
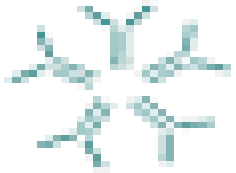
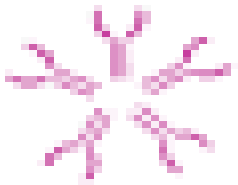
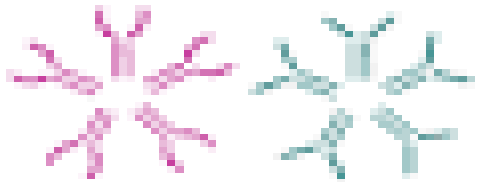
BLOOD GROUPS

- Blood groups are determined by the presence or absence of certain molecules on the surface of red blood cells.
- The two most common blood group systems are the ABO system and the Rh system.
- There are 4 main blood groups i.e.

1) Blood group A
2) Blood group B
3) Blood group AB
4) Blood group O

- When one has got less blood than necessary, blood transfusion is carried out. The one who gives blood to a patient is called a **donor** and the one receiving is known as a **recipient**.
- Doctors have to match the blood of the donor to that of the recipient because when incompatible blood is mixed, the red blood cells stick together (agglutinate) and blood clots. This is a fatal situation.
- Agglutination is caused by the presence of proteins called **antigens** on the surface of cells being mixed with specific **antibodies**, which work against them.
- Blood groups are determined by the type of antigens one has in blood. This means that one having antigen A belongs to blood group A.
- Those with antigen B belong to blood group B. Those with antigens A and B belong to blood group AB while those without antigens belong to blood group O.

- Each blood produces particular antibodies, which work against particular antigens when introduced into the body.
- For example, blood group A produces antibody b. This means that blood group A is anti (against) blood containing antigen B (blood group B).

	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

The table below shows the blood groups, the antigens they carry and the antibodies they produce.

Blood group	Antigen present	Antibody produced
A	A	b
B	B	a
AB	A and B	None
O	No antigen	a and b

Table of compatibility of blood groups

		RECIPIENT			
		A	B	AB	O
DONOR	A	√	X	√	X
	B	X	√	√	X
	AB	X	X	√	X
	O	√	√	√	√

RHESUS FACTOR SYSTEM

- Rhesus factor is a protein (antigen) also found on the cell membranes of the red blood cells.
- Many individuals have the Rhesus factor and are said to be rhesus positive (Rh+) while a few do not have the Rhesus factor and are said to be Rhesus negative (Rh-).
- The Rhesus factor was first discovered in a Rhesus Monkey hence its name.
- A person who is Rhesus factor positive can receive a successful blood donation without agglutination from a person of Rhesus positive and a person of Rhesus negative.

- However, a person who is Rhesus negative can only receive a successful blood donation without agglutination from his fellow Rhesus negative person though he can be transfused with blood which is Rhesus positive quite successfully only once and after this transfusion, his body produces antibodies against the Rhesus factor.
- Such antibodies attack the Rhesus factor with subsequent transfusion of Rhesus positive blood leading to agglutination.
- The same concept can be applied to pregnancy in that a Rhesus positive woman can successfully carry on a pregnancy where the fetus is Rhesus positive or Rhesus negative.

- A Rhesus negative woman can successfully carry a pregnancy where the fetus is only Rhesus negative; with such a woman, the first pregnancy with Rhesus positive fetus can be successful but during the pregnancy the woman's blood produces antibodies against the Rhesus factor. Such antibodies attack the Rhesus factor if the woman gets subsequent pregnancies where the Fetus is Rhesus positive.
- NB: During blood transfusion both the ABO system and the Rhesus factor system of blood groups are used together. So a person of blood group
- ARh+ can receive blood from a donor of (i) A Rh+ (ii) A Rh- (iii) ORh+ (iv) ORh-

IMPORTANCE OF KNOWING BLOOD GROUPS

- Knowing groups plays important role in determining compatibility for blood transfusions. If someone needs a blood transfusion, it is crucial to match their blood group with the donor's blood group to avoid potentially life-threatening reactions. For example, individuals with blood group A can receive blood from individuals with blood groups A or O, but not from individuals with blood group B or AB.
- Blood group compatibility is also important for organ transplants. The recipient's blood group must be compatible with the donor's blood group to minimize the risk of rejection. For example, a person with blood group O can donate organs to individuals with any blood group, making them a universal donor.

- During pregnancy, knowing the Rh factor of a woman's blood is impotant. If a Rh-negative woman is carrying a Rh-positive baby, there can be complications if the fetal blood mixes with the mother's blood. This can lead to the development of antibodies in the mother's blood that can harm future pregnancies. However, with proper medical intervention, these complications can be managed.
- Blood grouping can be useful in forensic investigations to determine the presence or absence of a particular blood group at a crime scene. This information can help in identifying potential suspects or ruling out individuals

The role of blood in the defence of the human body

Blood contains several components that actively participate in the body's immune response.

- **White Blood Cells (Leukocytes).** White blood cells are a key component of the immune system and are responsible for defending the body against infections.
- There are different types of white blood cells, including neutrophils, lymphocytes, monocytes, eosinophils, and basophils. Each type has its specific functions in combating pathogens. For example, neutrophils are involved in phagocytosis, lymphocytes are responsible for specific immune responses, and monocytes differentiate into macrophages, which engulf and destroy foreign substances.

- **Antibodies**. Antibodies, also known as immunoglobulins, are proteins produced by specialized white blood cells called B lymphocytes. These antibodies recognize and bind to specific foreign substances called antigens, such as bacteria, viruses, or toxins. By binding to antigens, antibodies mark them for destruction or neutralize their harmful effects, facilitating their elimination from the body.
- **Complement System**. The complement system is a series of proteins present in the blood that work together to enhance the immune response. It can directly destroy pathogens, attract immune cells to the site of infection, and assist in the process of phagocytosis.
- Platelets promote blood clotting

IMMUNITY AND THE IMMUNE SYSTEM

- If an animal contracts a bacterial or viral illness, however, it may eventually recover, even without medical intervention.
- Frequently, after recovering from an infection, the animal will be immune to (literally, "exempt” from) the disease-that is, it will not become ill when infected by the same pathogen in the future.
- **Immunity is a resistance to or protection from the symptoms caused by a disease-causing pathogen that invades the body**.
- The immune system is responsible for defending animals against pathogens.

- The immune response is based upon recognition of a foreign particle and the release of chemicals that destroy it. The foreign particle may be an antigen, bacteria, virus or any other pathogen.
- The substance that destroys these particles can be a white blood cell or antibodies produced by white blood cells.
- The body has three main lines of defence against disease. These involve mechanical barriers, chemical barriers and cells.

Mechanical barriers

- The surface of the skin as a barrier that stops them getting into the body. But if the skin is cut or damaged, the bacteria may get into the deeper tissues and cause infection.
- Hairs in the nose help to filter out bacteria that are breathed in. However, if air is breathed in through the mouth, this defence is by-passed.

Chemical barriers

- The acid conditions in the stomach destroy most of the bacteria that may be taken in with food.
- The moist lining of the nasal passages traps many bacteria, as does the mucus produced by the lining of the trachea and bronchi.
- The ciliated cells of these organs carry the trapped bacteria away from the lungs.
- Tears contain an enzyme called **lysozyme**. This dissolves the cell walls of some bacteria and so protects the eyes from infection.

Cells

- When bacteria get through the mechanical and chemical barriers, the body has two more lines of
- defence – white blood cells and antibodies, produced by white blood cells.
- One type of white blood cells fights infection by engulfing bacteria (a process called phagocytosis) and digesting them.
- Another type produce antibodies that attach themselves to bacteria, making it easier for other white blood cells to engulf them.

Types of immunity

There are 2 main types of immunity

1. Inborn or innate immunity

- This is the type of resistance to diseases that an individual is born with. It involves first and second lines of defense such as;

➢mucus and moist lining of the nasal passages trap many bacteria.

➢ Hairs in the nose help to filter out bacteria that are breathed in.

➢The surface of the skin as a barrier that stops them getting into the body.

➢ The acid conditions in the stomach destroy most of the bacteria that may be taken in with food.

➢The ciliated cells of these organs carry the trapped bacteria away from the lungs.

➢Tears contain an enzyme called **lysozyme**. This dissolves the cell walls of some bacteria and so protects the eyes from infection

2. Acquired (adaptive) immunity

- This is the type of immunity developed by the body during its life towards various diseases. It is divided into:
- Natural acquired immunity
- Artificial acquired immunity

a. Natural acquired immunity

- This is the immunity provided by antibodies which are naturally acquired. It is further divided into 2 types:
- Natural active immunity
- Natural passive immunity

I. Natural active immunity

- This is the type of immunity provided by antibodies produced by the body after being exposed to a particular disease. After production of the antibodies, the body becomes resistant to the subsequent similar infections e.g. contracting flu and recovering from it without using any drugs.

II. Natural passive immunity

- This is the immunity provided by antibodies acquired from another individual of the same species. It is a temporary type of immunity e.g. the body obtains anti bodies from the mother through breast feeding colostrum

Artificial acquired immunity

- This is the type of immunity provided by antibodies injected artificially from either the organisms of the same species or artificially made. It is divided into 2 types:

➢Artificial active immunity

➢Artificial passive immunity

I. Artificial active immunity

It is a product of inducing the body to produce antibodies by artificially injecting one with a vaccine (weakened/attenuated pathogenic organism). This process is called vaccination or immunization.

II. Artificial passive immunity

This is the immunity provided by antibodies artificially injected into an individual. It is temporary and the body is not induced to produce its own antibodies.

HOW DISEASES WEAKEN THE IMMUNE SYSTEM

HOW HIV VIRUS WEAKENS THE IMMUNE SYSTEM

- HIV attacks certain kinds of lymphocyte (called CD4+ T cells) so the number of these cells in the body decreases as the virus multiplies.
- Since the lymphocytes produce antibodies against infections and HIV reduces their number, the body cannot respond to infections through the immune system, it becomes vulnerable to pathogens that might not otherwise be life-threatening.
- As a result, the patient has little or no resistance to a wide range of diseases such as influenza, pneumonia, blood disorders, skin cancer or damage to the nervous system, which the body cannot resistand increases the risk of developing AIDS (Acquired Immunodeficiency Syndrome), which is the advanced stage of HIV infection.

The process of blood clotting

- When tissues are damaged and blood vessels cut, platelets clump together and block the smaller capillaries.
- The platelets and damaged cells at the wound also produce a substance that acts, through a series of enzymes, on the soluble plasma protein called fibrinogen.
- As a result of this action, the fibrinogen is changed into insoluble **fibrin**, which forms a network of fibres across the wound.
- Red cells become trapped in this network and so form a blood clot. The clot not only stops further loss of blood, but also prevents the entry of harmful bacteria into the wound.

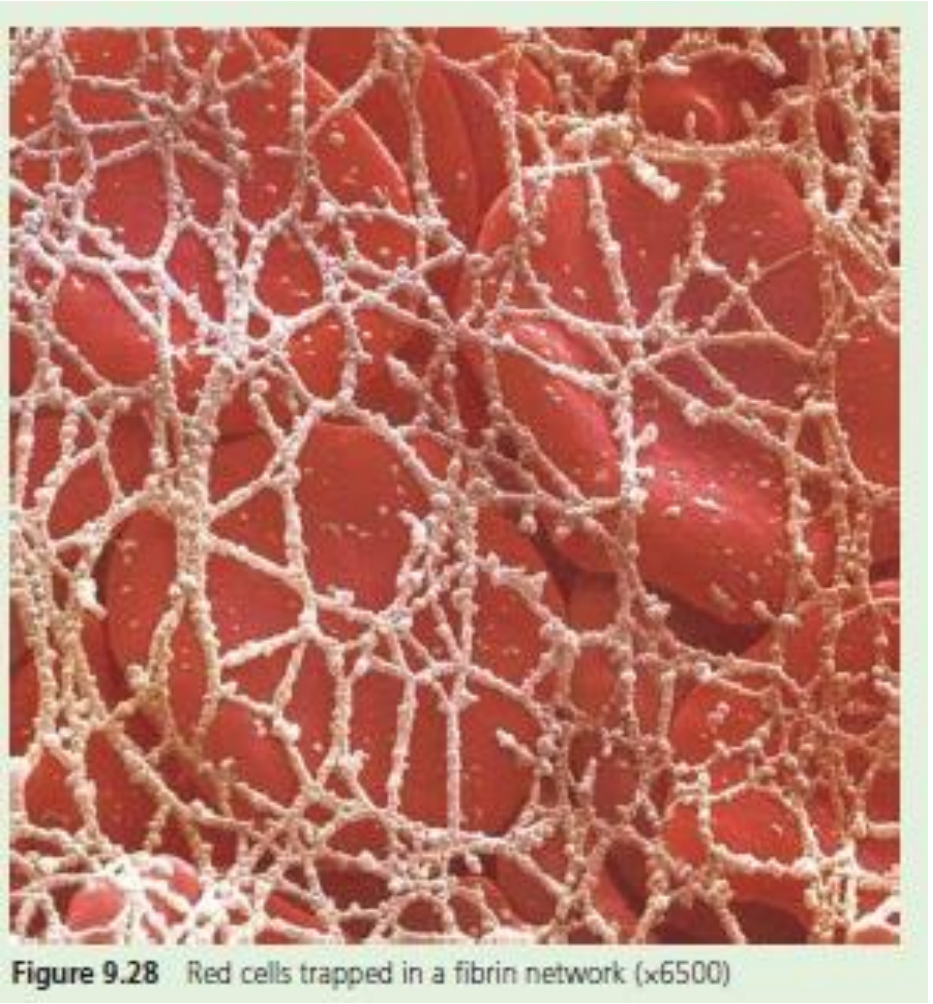


Figure 9.28 Red cells trapped in a fibrin network (×6500)

THE END

SLIDES PREPARED BY TR. EGABILE ALFRED

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