Transport in animals

Transport is the movement of materials from one part of the organism to another. Transport involves diffusion, and active transport in simple and small animal and at cellular level.

Big animals require a mass flow circulatory system to deliver food materials and other essentials and remove waste products from the cell. This is because big animals have small surface area to volume ratio that they cannot meet their transport requirement by diffusion.

Advantages for circulatory systems in big animals

1. Supplies metabolites and removes waste products from the cells at a faster rate than diffusion would do.
2. It enables separation of materials transported; e.g. oxygenated blood is transported different vessels from those that transport deoxygenated blood.
3. Impermeability of external surface to remove water. Example of thick cuticle of insects.
4. Avoids utilization of materials along the way.

Development of transport system in Animals

In the course of evolution, advanced organism attained a more advanced transport system than primitive one. This can be shown in the following examples:

1. Protozoans: transport their materials by cytoplasmic streaming. Simple diffusion across membrane surface, facilitated diffusion and active transport as well as pinocytosis and phagocytosis.
2. Cnidarians: transport by movement of body wall to create water current in their body cavity, which circulate food, water and dissolved gases.
3. Platyhelminthes: have very thin flattened shape enabling materials to be exchanged between the organism and the environment by diffusion.
4. Annelids have a coelom separating body wall from internal organs (gut) so needs a system between the two regions to enable food, gases and waste products to be transported between the regions. Earthworm has a closed blood circulatory system with pigmented blood.
5. Arthropods: have a hard exoskeleton so cannot depend on simple diffusion for the transport of materials between its tissues and the environment. They use a tracheal

system to transport oxygen and carbon dioxide and have a haemocoel containing a colorless blood in which organs are suspended. Thus, the body organs are in direct contact with blood. The blood does not transport oxygen and therefore does not contain haemoglobin.

6. Vertebrates: circulatory system has muscular heat to pump blood through blood vessels throughout the body.

Features of circulatory systems

1. Transport medium or blood to carry dissolved materials such as food oxygen and carbon dioxide.
2. Vessels to carry the medium to all parts of the body
3. A pump to propel the medium in the vessel
4. One- way values to keep the medium flowing in one direction
5. A close association between the tissue and medium so that the cell can obtain the required substances from the medium and deliver their waste products to it.

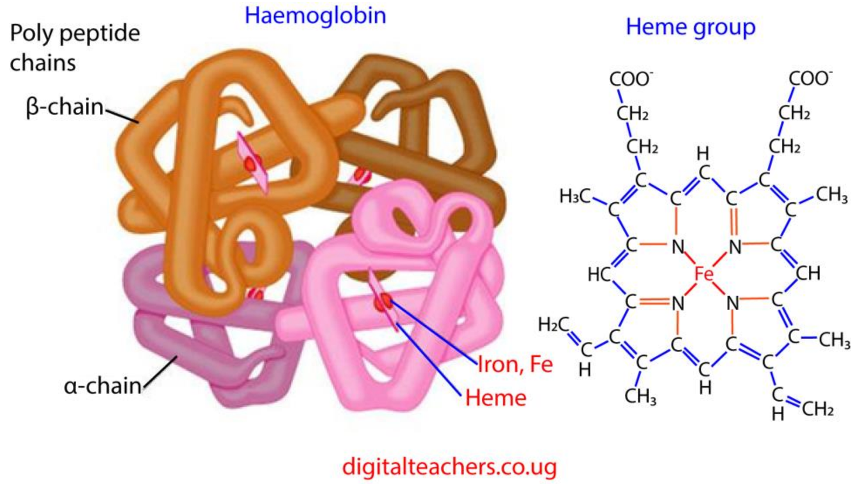
A. Transport medium

A few animals have a type of blood, which is more or less like seawater. One of the substances to be transported is oxygen. To increase oxygen carrying capacity of water most active animals have pigments in their blood. In most species, the pigment is contained in special cell but in some species is free in the fluid part of blood the plasma.
Each pigment consists of a prosthetic group and a protein.

Comparison of oxygen carrying pigments

Pigment	Metal in prosthetic group	Color of pigment	Example of animals	
Hemoglobin	Iron	red	vertebrate	Plasma or cells
Hemocyanin	Copper	blue	arthropods	plasma
Chlorocruorin	iron	green	annelid	plasma
Hemerythrin	iron	violet-pink	sipunculids, priapulids, brachiopods	Cells or plasma

Structure of hemoglobin



Structure of haemoglobin

(i) Hemoglobin comprises four subunits, each having one polypeptide chain and one heme group.

(ii) The polypeptide chains of adult hemoglobin are of two kinds, similar in length but differing in amino acid sequence.

(iii) The two alpha chains each has 141 amino acid residue while the two beta chains each has 146 amino acid residues

(iv) Heme, which accounts for only 4 percent of the weight of the molecule, is composed of a ring-like organic compound known as a porphyrin to which an iron in oxidation state II is attached.

(v) Oxygen binds reversibly to the ferrous iron atom in each heme group.

(vi) The binding of oxygen to the heme group of one subunit has an effect of increasing the affinity of a neighboring subunit (on the same molecule) for oxygen.

Functions of hemoglobin

a. The main function of hemoglobin is to carry oxygen from the lungs to all the tissues of the body.

b. Some of carbon dioxide is transported from tissues to lungs through hemoglobin. Although the majority of it is transported via plasma but still it carries some of CO_2 to lungs.

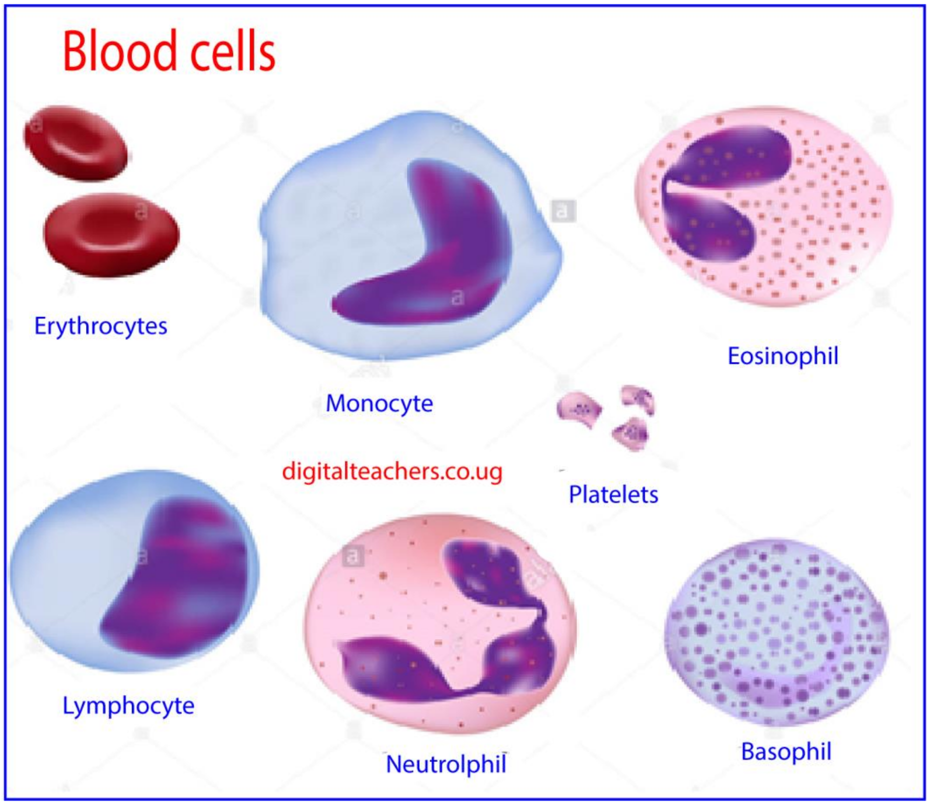
c. Buffering action:
Hemoglobin also acts as a buffer. Buffer is a substance that resists change in pH. Blood has pH of 7.4 and it remains in the narrow range, because, if it changes, the life of the person may be endangered.

d. Interaction with drugs: For not only oxygen, but also hemoglobin act a very important role the transport of various drugs to their site of action.

The blood
Blood is a specialized tissue consisting of several types of cells suspended in fluid medium called plasma.

Functions of mammalian blood
1. Transport of soluble organic compounds from the small intestine to various parts of the body.
2. Transport of soluble excretory matters to organs of excretion.
3. Transport of hormones from glands where they are formed to target organs.
4. Distribution of heat in order to maintain the body temperature
5. Defense against diseases, which may be obtained through blood clotting, phagocytosis and immunity.
6. Maintenance of a right blood solute potential as a result of plasma proteins activity.
7. Transportation of respiratory gases i.e., CO_2 &O_2

Components of blood
1. **Water:**
   This maintains blood pressure and volume. It’s where dissolved materials are transported around the body. Pressure is particularly important since the glomerulus require high pressure to form urine.
2. **Plasma proteins:**
   These include
   (i) *Serum albumen;* abundant to increase the viscosity of blood and binds with calcium. Calcium is important for the functioning of enzymes.
   (ii) Serum globulin which include
      - α-globulin, which binds with and transports hormone thyroxine, lipids and fat-soluble vitamins; A, D, E, K.
      - β-globulin, binds and transport iron, cholesterol and fat soluble vitamins; A, D, E, K.
      - γ-globulin are antibodies produced by lymphocytes for immune response.
   (iii) *Prothrombin*- a catalytic agent involved in blood clotting.
   (iv) Fibrinogen- a protein involved in blood clotting.
   (v) *Enzymes*- that control rate of metabolic activities in blood.
   (vi) *Mineral salts:* include Na^+, K^+, Ca^{2+}, Mg^{2+}, HPO_4^{2-},HCO_3^-, Cl^-, etc. they regulate osmotic pressure and pH level of blood. Ca2+ helps nervous transmission and blood clotting.
   (vii) *Dissolved products od digestion, excretory products, vitamins and hormones* that are transported in the body



(a) **Erythrocytes:** Produced in the liver in infants, embryo and cartilaginous organisms or in bone marrow in those organisms that have bones. Their function is to carry oxygen.

Adaptations of red blood cells to its function

1. They have a biconcave disc shape to increase the surface area for absorption of oxygen.
2. They lack a nucleus, which permits haemoglobin to be packed into the cell.
3. They are small therefore able to squeeze between capillaries
4. They have a thin membrane permitting efficient diffusion of gases (short distance for diffusion)
5. They contain haemoglobin, which has a high affinity for oxygen.
6. They do not carry out any metabolism so they do not utilize the oxygen being transported.

Carriage of oxygen

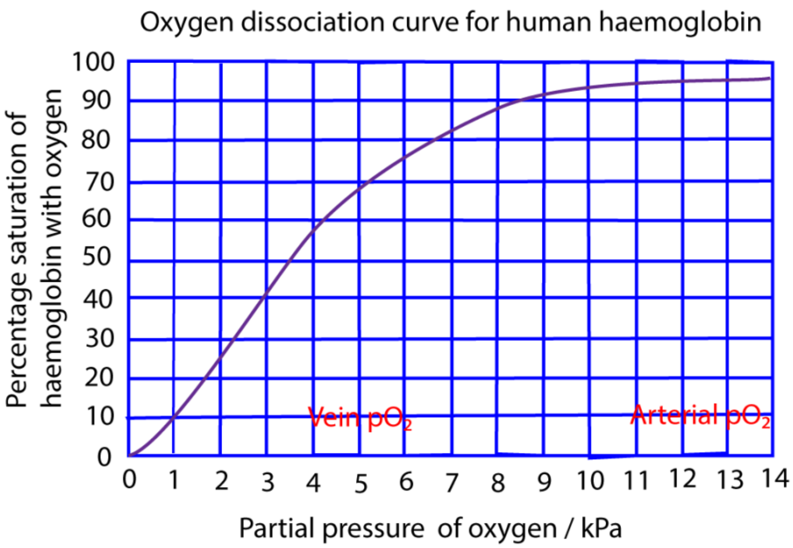
Oxygen diffuses into the red blood cells across its plasma membrane and combines with the haemoglobin to for oxyhemoglobin. The attachment of oxygen does not involve chemical oxidation of iron which remains in Iron (II) state throughout the process. The union is a loose one, the oxygen molecule being attached to haemoglobin in the lungs and equally readily detached in the tissues.

Efficiency of haemoglobin as oxygen carrier
When one of the four polypeptide chains in haemoglobin molecule receives oxygen molecule in the lungs its structure is altered in such a way that the remaining three polypeptide chains accept oxygen readily. In the tissue the reverse occur: one of the polypeptide chains loses its oxygen molecule and this causes the others to give up their oxygen more readily. In other words, haemoglobin takes up oxygen more rapidly if it already possesses one or more oxygen molecules, and releases it more rapidly if it has already released one or more oxygen molecules.

Oxygen dissociation curve
The ability of blood to transport enough oxygen to meet the needs of the body is largely attributed to the affinity of haemoglobin for oxygen.

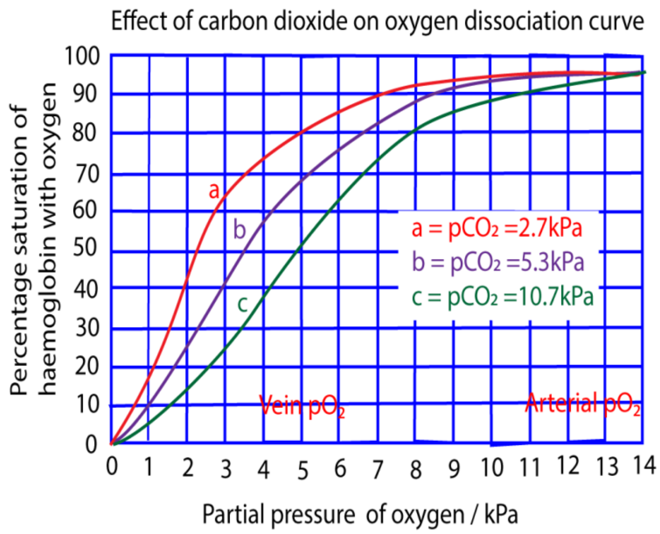
This can determined by exposing a sample of blood to different partial pressures of oxygen (concentration of oxygen in air), and then determining the percentage saturation of blood with oxygen in each case.

A plot of percentage saturation of haemoglobin with oxygen against partial pressure of oxygen gives an oxygen dissociation curve below



Oxygen dissociation curve is S-shaped (sigmoid) showing that it is very appropriate for a blood pigment. Over the steeply rising part of the curve, a small increase in the partial pressure of oxygen achieves a relatively high percentage saturation of blood.
The flat part of the curve at the top corresponds to the situation in the lungs: over this range a high saturation is maintained even if the partial pressure of oxygen in the alveoli falls.

The oxygen dissociation curve favors the loading oxygen in the lungs and offloads of oxygen the tissue.



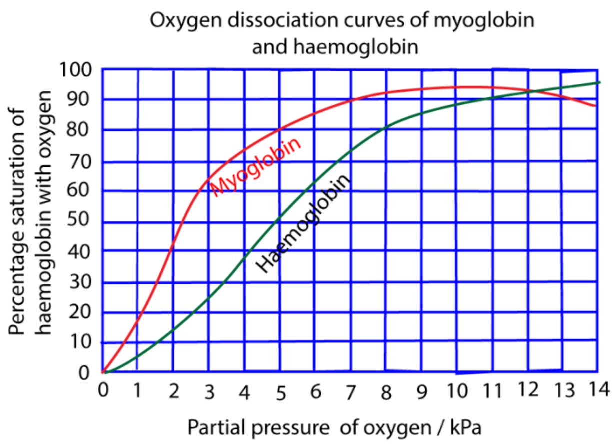
The graph above shows that a high concentration of carbon dioxide shifts the curve to the right. i.e. it lowers the affinity of haemoglobin for oxygen. The release of oxygen is therefore favored in the tissue where the partial pressure of carbon dioxide tends naturally to be high as result of its continual release from respiring cells. The oxygen uptake occurs in the lungs where the partial pressure of carbon dioxide is low.

In summary the affinity of haemoglobin for oxygen is reduced by

- Low oxygen concentration.
- High carbon dioxide concentration
- High body temperature
- Low PH

High carbon dioxide concentration (or low PH) has the effect of establishing deoxyhaemoglobin.

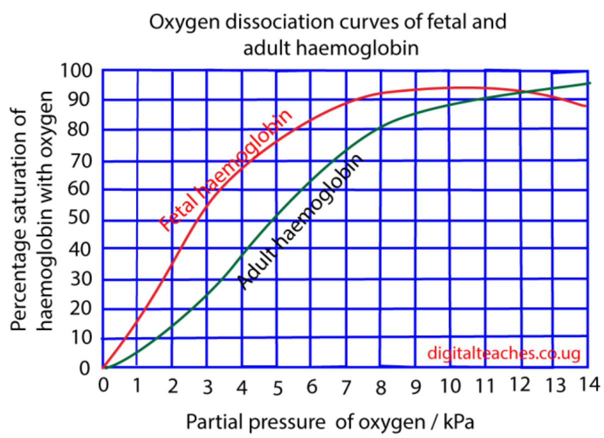
This favors the unloading of hemoglobin hence reducing its affinity for oxygen.



The oxygen dissociation curve of myoglobin lies at the left of that of hemoglobin because myoglobin has a high affinity for oxygen. Myoglobin is found in muscles; it picks from hemoglobin and stores oxygen to be used when the partial of oxygen falls to a very low level as in severe muscle exertion.

Similarly, the hemoglobin of animals like lungworm, which burrow in oxygen-deficient mud, has higher affinity for oxygen than hemoglobin.

Location of the oxygen dissociation curve of an organism to the left of another usually indicates higher affinity for oxygen by its haemoglobin. Thus, the mountain gorilla has a high affinity for oxygen then many other animals. This allows its haemoglobin to get saturated at low oxygen tension. This enables it to survive in condition of low oxygen partial pressure at high altitudes



The oxygen dissociation curve of fetal hemoglobin lies at the left of that of hemoglobin; this this because fetal hemoglobin has a high affinity for oxygen than adult hemoglobin this enable fetal hemoglobin to pick oxygen from the mother's blood.

Effect of carbon monoxide on oxygen carriage of hemoglobin

Carbon monoxide combines more readily with hemoglobin than oxygen. This prevent hemoglobin to combine with oxygen, thus carbon monoxide is powerful respiratory poison.

Transport of carbon dioxide

CO_2 react with water to produce carbonic acid H_2CO_3. In the red blood cells the reaction is catalyzed by carbonic anhydrase.

$$CO_2 + H_2O \longleftrightarrow H^+ + HCO_3^- \longleftrightarrow 2H^+ + CO_3^{2-}$$

Carbonic acid dissociate into hydrogen ions. Hydrogen ions combine with haemoglobin to form haemoglobinic acid while HCO_3^- diffuses into blood.

The electroneutrality in the red blood cells is maintained by an inward movement of chloride ions from the plasma so- called **chloride shift**.
In the lungs, hydrogen ions combine with hydrogen carbonate ions to give CO_2 which is lost to atmosphere.

(b) White blood cells

These are produced in the bone marrow and are of various types:

a. Granulocyte; these constitutes 72% of the total leucocytes. They have an irregular lobed nucleus and a cytoplasm containing granules. The granulocytes are divide in 3 types.

(i) The granules of *neutrophils* remain unstained when a dye, eosin is applied to them.
(ii) *Eosinophils*: stain red with the eosin dye. They are one of the immune system components responsible for combating multicellular parasites and certain infections in vertebrates. They possess anti- histamine properties, which help to reverse allergic conditions. E.g. asthma or hay fever
Bosophils. These stain blue with eosin dye. The cells produce heparin an anticlotting hormone and histamine in inflammation.

b. Agranulocytes;

These have a rounded or bean shaped nucleus. Their cytoplasm has no granules They include lymphocytes and monocytes.

(i) Lymphocytes
These have a rounded nucleus with no cytoplasmic granules. They originate from the lymph nodes and cause antibody production and immediate immune reactions such as willing of tumors, grafts etc.

(ii) Monocytes
These are formed in the bone marrow and have a bean shaped nucleus. They are phagocytes and ingest bacteria

c. **Platelets;** are produced in bone marrow and initiate blood clotting.
These are irregularly shaped membrane bound cell fragments frequently nucleated and made from the bone marrow. They are used in blood clotting.

B. Vascular systems in Animals

There two types of vascular systems: **open** and **closed vascular systems.**

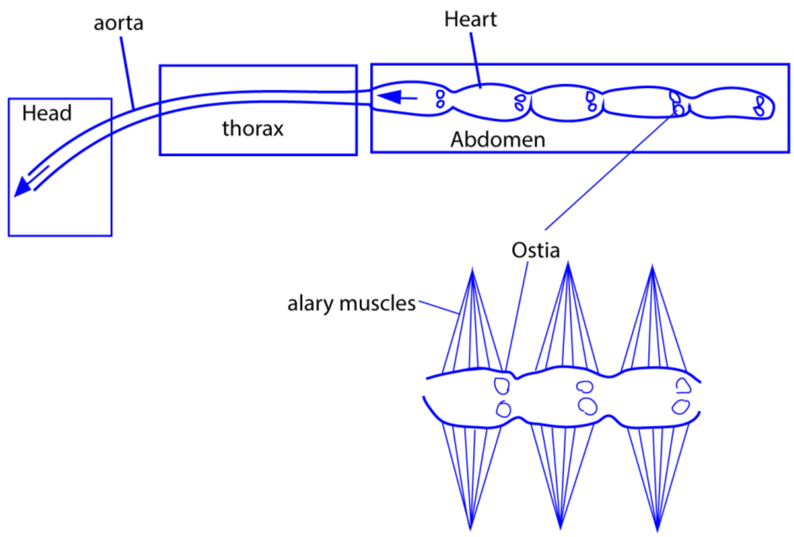
(a) The **open vascular system:** (most arthropods, some cephalad molluscs, tunicates).
Blood is pumped by heart into an aorta which branches into a number of arteries. These open into a series of blood spaces collectively called **haemocoel.** Here cells are in contact with the blood and materials are exchanged by direct diffusion through the plasma membrane.

Blood under low pressure blood moves slowly between tissues gradually percolating back into the heart via open-ended veins. Distribution of blood in tissue is poorly

0controlled. This limits the efficiency of the open system.

Fortunately, gaseous exchange in insects takes place through the tracheal system. The insect circulatory system is not therefore concerned with transporting oxygen and carbon dioxide. Accordingly, it lack an oxygen carrying pigment. However, it plays an important role in distributing food substance and eliminating nitrogenous waste.

Circulatory system of an insect



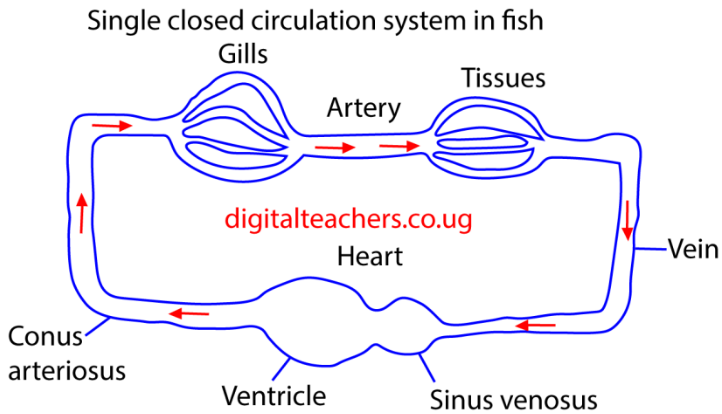
(b) **The closed vascular system:** (echinoderm, cephalo, molluscs, annelids, vertebrate). Here blood is confined in a series of specific vessels and not permitted to touch the body tissues. In animals with a closed system the heart more muscular heart and blood is pumped by the heart rapidly around the body under sustained high pressure and back to the heart. Material exchange occurs across the wall of **blood capillaries**, which ramify through the organs and come into close association will all cells. Animals with closed systems are generally larger and often more active.

The disadvantage of closed circulatory system is that the blood is contained in vessels whose walls form a barrier between the blood and the surrounding tissues. Oxygen and other materials have to cross this barrier. However, capillaries having very thin walls reduce this barrier.

(i) Single closed circulatory system

Here blood possesses through the heart once in every circuit of blood.

In fish, for example, blood is pumped from the heart to the gills. After acquiring oxygen from the gills, blood flows to the body tissues and then back to the heart.



The problem with this arrangement is that blood has to pass through two capillary systems, the capillaries of the gills and then those of the body, before returning to the heart. Capillaries offer considerable resistance to the flow of blood, and this means that in fishes there is marked drop in blood pressure before the blood completes a circuit. For this reason the blood flow from tissues to the heart is sluggish. This is overcome to some extent by the fact that fishes have large **sinuses,** which offer minimum resistance to blood flow, in places of veins. Nevertheless, the problem of getting blood back to the heart is an acute one and probably imposes severe limitation on the activities of many species of fish.

(ii) Double Circulation

In double circulation blood passes through the heart twice in every complete circuit.

Advantage

- Blood is pumped to the lungs at a much lower pressure than that at which it is pumped to the rest of the body. In human the pressure in the pulmonary artery is about one - sixth of that in aorta.
- Deoxygenated blood is separated from oxygenated blood and then pumped at different pressure to the lung and the body respectively.

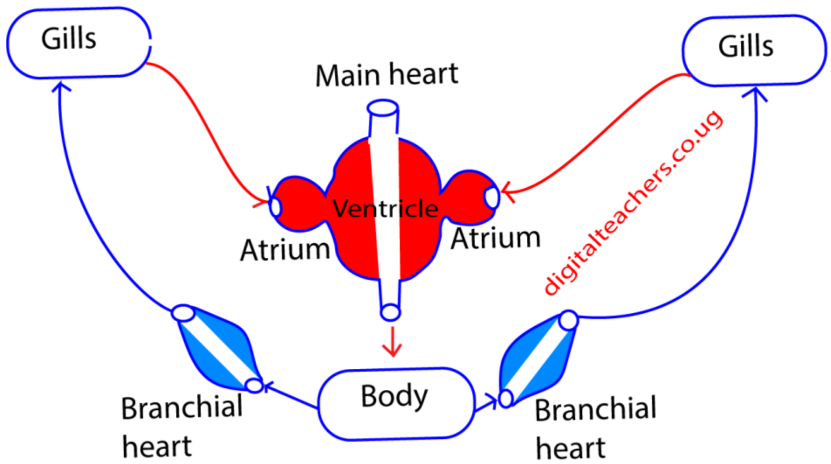
(iii) Incomplete double circulation

A frogs heart has two atria and one ventricles, however, blood mixing in the ventricle is prevented by the **spiral valve** in the **conus arteriosus** a heart chamber immediately before blood is pumped into big arteries.

(iv) Separate hearts

The squids and octopuses solved the pressure problem by having two having two hearts: blood is pumped from the main heart to various parts of the body. It the flows through a system of sinuses to a pair of branchial hearts which pump it to the gills.

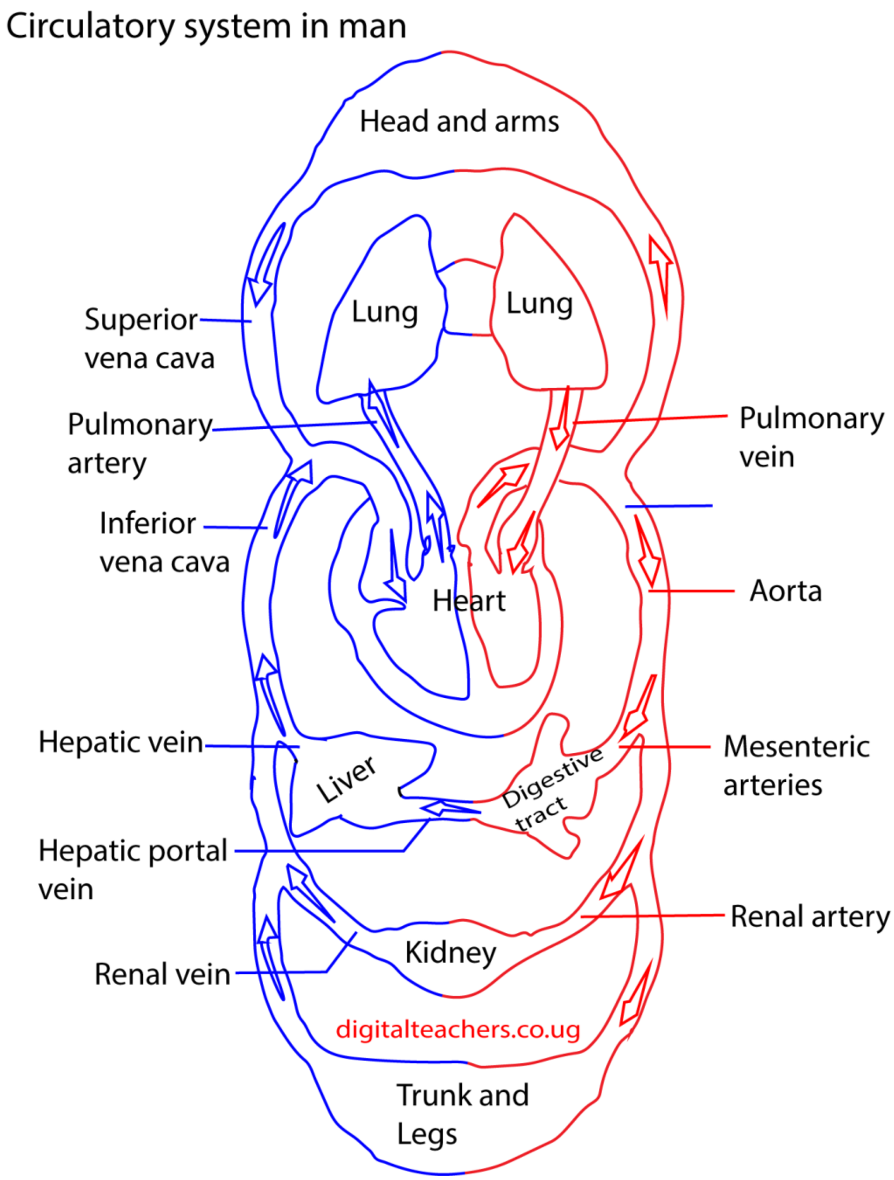
Double circulation in squid and octopus



The Human circulatory

The circulatory system consists of three independent systems that work together: the heart (cardiovascular), lungs (pulmonary), and arteries, veins, coronary and portal vessels (systemic). The system is responsible for the flow of blood, nutrients, oxygen and other gases, and as well as hormones to and from cell

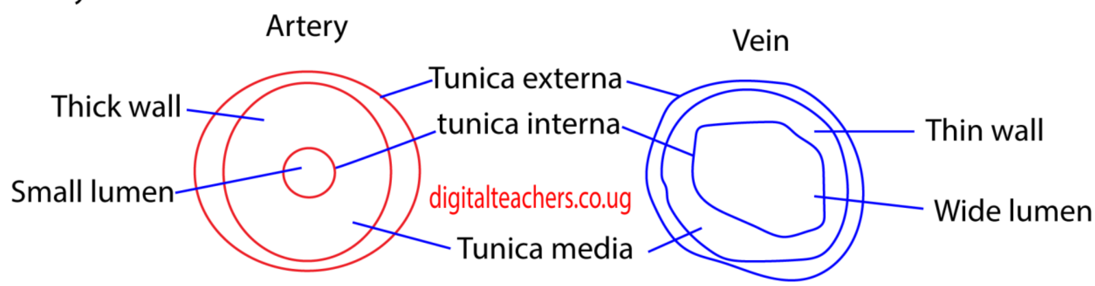
The figure below shows the main blood vessel in the human Circulatory system



Arties and vein

Arteries transport blood at high pressure to the body while veins transport blood at low pressure from the body to the heart.

Artery and vein



Adaptation of the artery
-thick wall to accommodate high pressure
- have a narrow lumens to maintain high pressures
- some arteries like aorta valves to prevent back flow of blood.

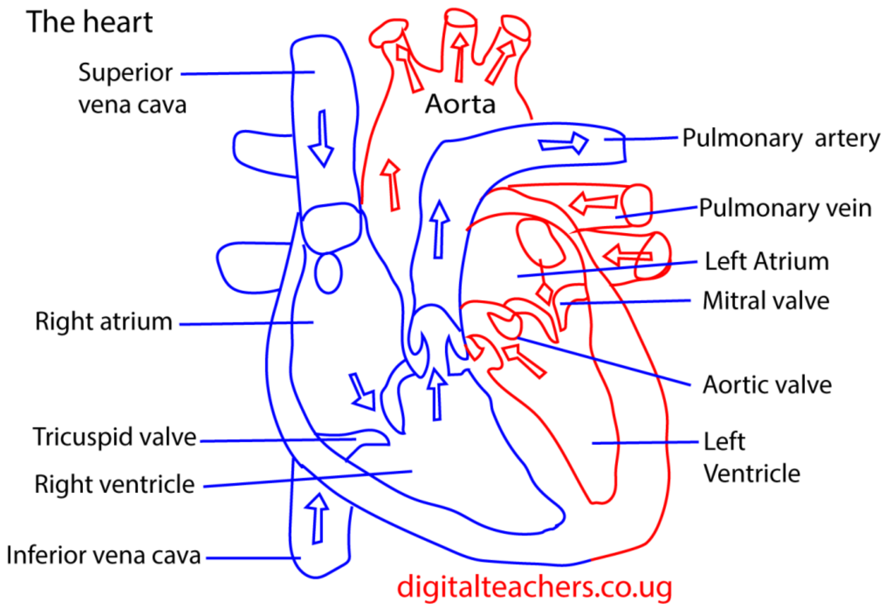
Adaptation of veins
-wide lumen to lower resistance to blood flow
-valves allow blood tom flow in one direction

Differences between arteries and veins

	Arteries	veins
1	Thick wall	Thin walls
2.	Narrow lumen	Broad lume
3.	Have no valves except pulmonary artery and aorta	Have valves
4.	Carry oxygenated blood except pulmonary artery	Carry deoxygenated blood except
5.	Pulse detectable	Pulse not detectable
6.	Empty at time of death	Get filled up at death.

Capillaries
Is where exchange believe blood and cell takes place

Adaptation of capillaries
-thin walls for fast diffusion



Blood returning via the venae cava enters the right atrium. The resulting pressure in this chamber forces open the flaps of the **tricuspid valve.** The result is that blood flows through the atrioventricular opening into the right ventricle.

When the atrium and ventricle are full of blood the atrium suddenly contracts, propelling the remaining blood into the ventricle. The contraction spreads from the right atrium over the rest of the heart. A trial systole is relatively weak but the ventricles, whose thick walls are particularly well endowed with muscles, contract more powerfully. As a result, blood is forced from the right the ventricle into the pulmonary artery.

The blood is prevented from flowing back into the atrium by the flaps of the atrio-ventricular opening. The atrio-ventricular valve is prevented from turning inside out by tough strands of connective tissue, the tendinous cord or "heart strings" which run from the underside of each flag to the wall of the ventricle

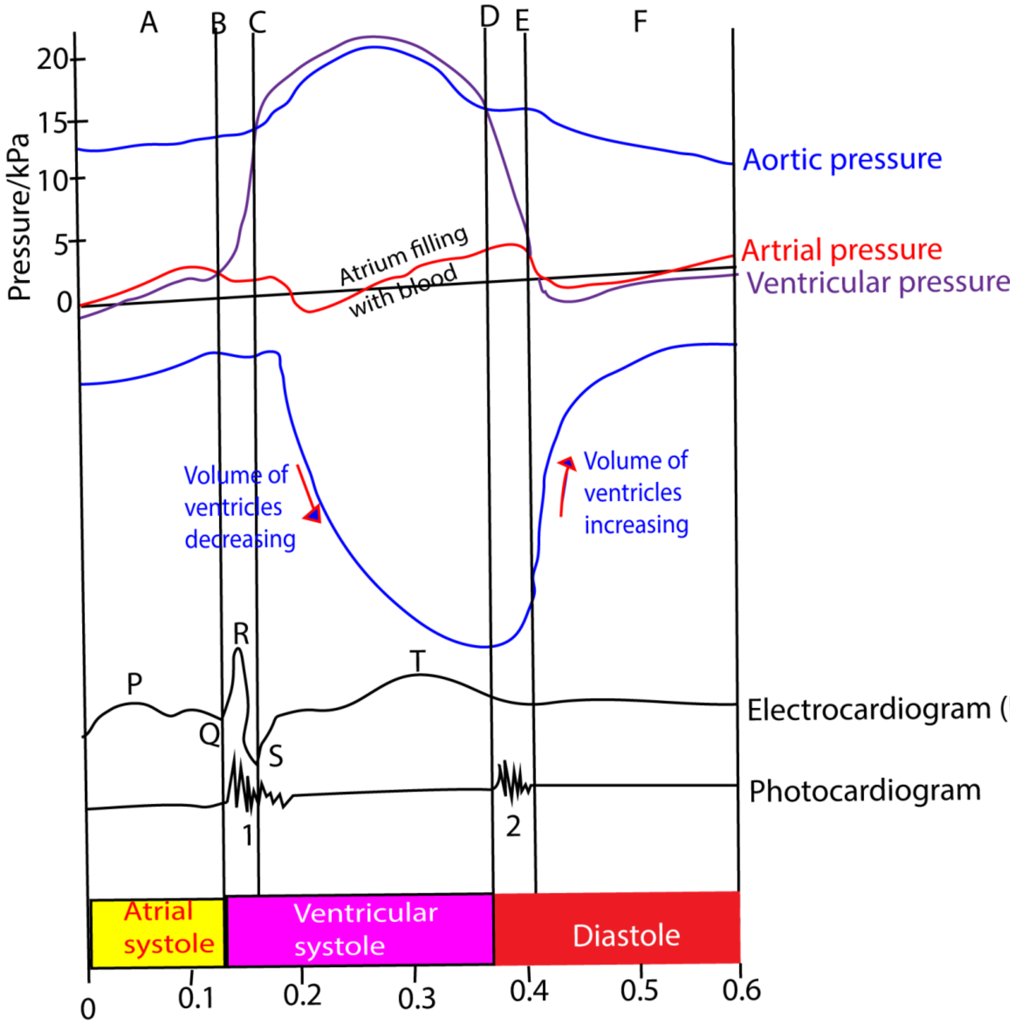
Once in the pulmonary artery, blood is prevented from flowing back into the ventricle by pocket like **semilunar** valves guarding the opening of pulmonary artery.

From the lungs oxygenated blood returns to the left atrium via the pulmonary veins. It is then conveyed to the left ventricle and so into the **systemic arch** which leads to the **aorta.** The flow of blood takes place in the atrioventricular valve consists of two flaps rather than three, for which reason. It is called the **bicuspid valve.** It is also known as the **mitral valve** because its two flaps are rather like a bishop's miter.

Although systole starts at the right atrium, it quickly spreads to the left so that the whole heart appears to contract synchronously. The de-oxygenated blood is pumped from the right ventricle into the pulmonary artery at the same time as oxygenated blood is pumped from the left ventricle in the aortic arch.

Systole is followed by diastole during which the heart refills with blood again. The entire sequence of events is known as the **cardiac cycle**.

The graph below illustrates the pressure and volume changes that occur during mammalian cardiac cycle (dog). Pressure changes were measured in the left atrium, ventricle and the aorta. Volume changes were measured for both ventricles. The electrical activity in the heart wall (Electrocardiogram) and heart sound (Phonocardiogram) as recorded in human subject are also shown.



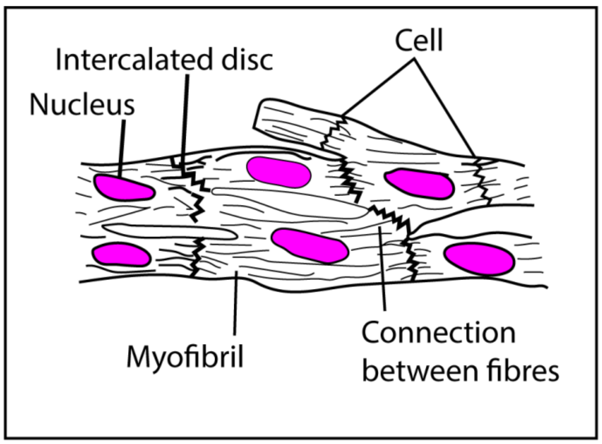
The actions at different points on the graph are described below

A Atrium starts to contract: blood flows into ventricle
B ventricle starts to contract: ventricular pressure exceeds atrial pressure; atrioventricular valve close
C Ventricular pressure exceeds aortic pressure, forcing aortic valve to open; blood flows from the ventricle and ventricular volume falls
D Ventricular pressure falls below aortic pressure; aortic valves close

E Ventricular pressure falls below arterial pressure; blood flows from atrium to ventricle; ventricular volume raises rapidly.
F Atrium continuing to fill with blood from pulmonary vein; atrial pressure exceeds ventricular pressure so blood flows from atrium to ventricle

Cardiac muscle

The most remarkable feature of the heart is the ability to contract rhythmically without fatigue. It owes this property to its muscle know as cardiac muscle. The muscle consists of a network of interconnected muscle fibres.



The fibres are divided up into uni-nucleated cells containing myofibrils. The interconnection (intercalated discs) between **the fibers ensure a rapid and uniform spread of excitation** throughout the walls of the heart which in turn ensure a uniform contraction.

Beating of the heart

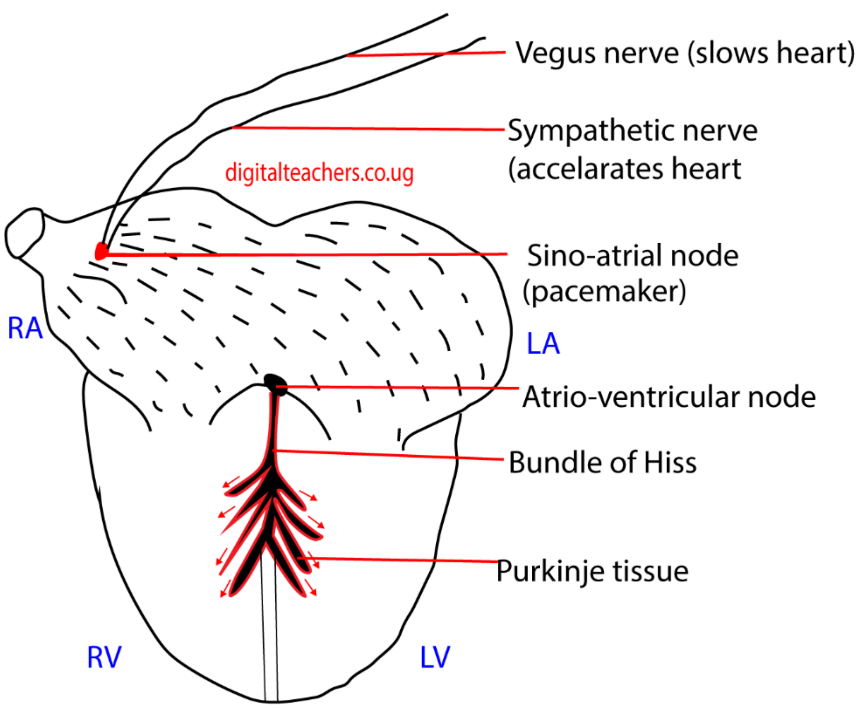
Cardiac muscle is myogenic, that is, generate rhythmical contraction from within it muscle. The heart rhythm is initiated by specialized plexus (network) of fine cardiac muscle fibres embedded in the walls of the right atrium close to where the vena cava enters the heart, called sino atrial node (SAN) or the pacemaker. The contraction of the heart is preceded by a wave of electrical excitation from SAN and then spread over the heart atria. When the wave reaches the junction between the atria and ventricle, it excites another specialized group of modified cardiac muscle fibres called the atrio-ventricular node (AVN), Continuous with the AVN is a strand of modified cardiac muscles fibres called Bundle of Hiss. This runs down the inter-ventricular septum and fans out over the walls of the ventricle where it breaks up into a network of fibres called Purkinje tissue just beneath the endothelial lining.

When the AVN receives excitation from the atria, it sends impulses down the bundle of Hiss to purkinje tissue. The impulse then spread out to the cardiac muscle tissue in the walls of the ventricle making it to contract.

The role of AVN is delay electrical impulse from the atria to the ventricle to allow atria contract before the ventricle.

The purkinje tissue ensure slow uniform spreading of excitation to the ventricle after the contraction of the atria.

The ventral view of heart showing the spread of electrical beating of the heart initiated by the pacemaker, the nerves simply serve to speed up or slow down the heart



Control of contraction

The cardio vascular center in the medulla of the brain controls the rate of heartbeat. Depending on circumstance, the cardiovascular center sends impulse down the sympathetic nerve to the heart, increasing its rate of heart beat or down the vegus nerves decreasing the rate of heartbeat.

Physiological adaptations of diving mammals

Physiological adaptations of diving animals include increased blood volume and elevated hematocrit (proportion of red blood cells per unit volume), hemoglobin, and myoglobin, whereas oxygen-use rates are minimized via regulation of metabolism, heart rate, and peripheral vasoconstriction

Objective questions

1. The oxygen dissociation curves for aquatic animals are usually to the left of those of terrestrial ones because

A. there is less oxygen in water.
B. air is less dense than water.
C. aquatic animals are less active.
D. aquatic animals use less oxygen.

20. Which one of the following is the correct order of events in the heart after the contraction of the atria?

A. Atrio -ventricular valves open, ventricles contract, semi lunar valves close.

B. ventricles contract, atrio-ventricular valves close, semi lunar valves open.

C. ventricles contract, atrio-ventricular valves semi lunar valves open.

D. Atrio- ventricular valves open, semilunar valves open, ventricles contract

22. High concentration of carbon dioxide in the tissues leads to

A. Increase in the affinity for oxygen by haemoglobin.

B. Increase in the loading tension of haemoglobin.

C. Shifting the dissociation curve to the left.

D. Lowering of the affinity for oxygen by haemoglobin.

13. The increase in supply of blood to heart respiring tissues, is caused high

A. ventilation rate.

B. concentration of oxygen in the inhaled air.

C. carbon dioxide concentration in the blood.

D. carbon dioxide concentration in the tissues.

24. The lack of a nucleus in the red blood cells enables it to

A. have a high affinity for oxygen.

B. be more permeable to oxygen.

C. give up oxygen more readily.

D. contain more haemoglobin.

19. High carbon dioxide concentration in respiring tissues is important because it causes

A. local vasodilation, allowing more blood into the tissues.

B. low pH in the tissues leading to unloading of oxygen.

C. local vasoconstriction creating high blood pressure.

D. increased heartbeat.

32. Mixing of oxygenated and deoxygenated blood in amphibians is minimized by

A. rapid contraction of the ventricle.

B. spongy nature of heart muscles.

C. spiral valve in the truncus arteriosus.

D. columnae carnae in the ventricular

31. An organism living in a oxygen deficient environment has

A. haemoglobin that easily picks up oxygen.

B. its oxygen dissociation curve to the right.

C. haemoglobin that readily releases its oxygen.

D. haemoglobin that less readily picks up oxygen

16. Blood flows in the heart of an insect as a result of

A. raising the perivisceral membrane.

B. contraction of the alary muscles.

C. relaxation of the heart ligaments.

D. increase in the pericardia! pressure.

35. The lung fish living in mud has its oxygen dissociation curve to the left of that for humans because

A. there is a high level of carbon dioxide concentration in the mud.

B. the lung fish's haemoglobin has a higher affinity for oxygen than that of humans.

C. of the lower temperature of the h

D. of low level of oxygen concentration in the mud.

39.Which one of the following when at high levels in the blood, increases the rate of heart beat?

A. Carbon dioxide.

B. Thyroxine.

C. Oxygen.

D. Adrenaline.

8. Which one of the following describes the chloride shift during transportation of carbon dioxide in mammals?

A. Hydrogen carbonate ions leave the erythrocytes as chloride ions from tissues, enter.

B. Chloride ions leave the erythrocytes as hydrogen carbonate ions from tissues, enter.

C. Chloride ions enter the lungs as hydrogen carbonate ions leave the erythrocytes.

D. Hydrogen carbonate ions enter the lungs as chloride ions leave the erythrocytes.

14. Oxygen from myoglobin is released after oxy-haemoglobin supplies are exhausted because myoglobin

A. **acts as a store of oxygen in resting muscles.**

B. works better when the partial pressure of oxygen is high.

C. is produced in skeletal muscles when the oxygen demand is low.

D. has a lower affinity for oxygen than haemoglobin.

31. The correct order of transmission of electrical impulses to initiate the heart beat is

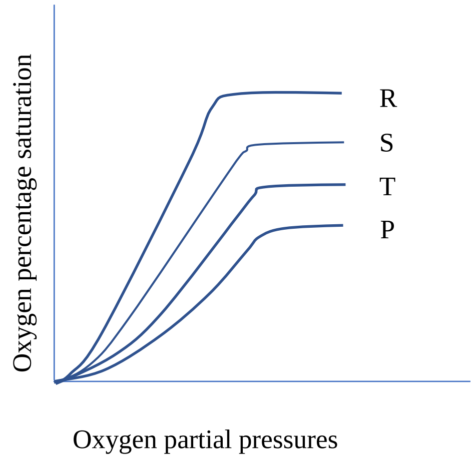
A. **sino-atrio node — artria — atrio-ventcular node — purkinje tissue —ventricles.**

B. sino-atrio node — ventricles — atrio-ventricular node — purkinje tissue— atria

C. atrio-ventricular node — atria — sino-atrio node — purkinje tissue — ventricles

D. atrio-ventricular node — purkinje tissue — ventricles — artria — sino-artrio node.

33. Figure 4 shows the oxygen dissociation curves for mudfish, human foetus, adult human and an active flying bird.



Which curve is most likely to be that of an active flying bird?

A. R.

B. S.

C. T.

D. P.

30. Which one of the following conditions reduces the affinity of hemoglobin for oxygen?

A. High oxygen concentration.

B. High carbon dioxide concentration.

C. Low body temperature.

D. High pH of the blood.

36. Which one of the following is responsible for increasing the pressure of blood flowing in veins, back to the heart?

A. The pumping action of the heart.

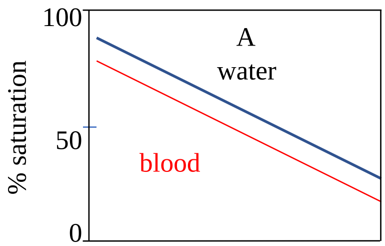
B. Contraction of skeletal muscles.

C. Closing of valves.

D. Inspiratory movements of muscles.

Structured questions

46. Figure 6 illustrates two different mechanisms of gaseous exchange in fish A and B



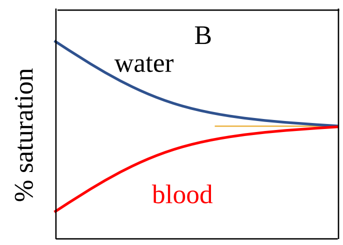


Fig. 6

(a) State two differences between the two systems of oxygen concentration (2marks)
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(b) Explain the physiological advantage of fish A over B(2marks)
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(c) Describe how a gill is structurally adapted as a respiratory surface (4marks)
……………………………………………………………………………………………………
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………………..

Solution

(a)

Differences

Fish A	Fish B
-oxygen concentration of blood is above 50% at the end of the gill plate. - water always has a higher oxygen concentration than blood	-oxygen concentration of the blood is about 50% at the end of the gill plate. Initially water has a higher oxygen concentration, but at the end of the gill plate, the oxygen concentration blood and water

Other Oxygen concentration of the blood increase linearly along the gill plate.	are the same. Oxygen concentration of the blood increase first rapidly then decreases gradually and reaches a constant valve at 50%

(b) Fish A maximizes gaseous exchange than fish B

Fish A maintains a steep concentration gradient between the water and blood that the fish picks up enough oxygen from the water and deposits sufficient quantities of excess carbon dioxide in it.

(c) Highly folded into filaments to increases surface area gaseous exchange

- It is covered with a thin highly permeable membrane to reduce the diffusion distance.
- It has a rich blood to increases the efficiency to gaseous exchange.
- It's wet in order to increase chance of picking up gases readily dissolve in the moisture.
- Numerous filaments increase the surface area

1. Figure 7 shows the oxygen dissociation curve for a tadpole blood and that of adult frog

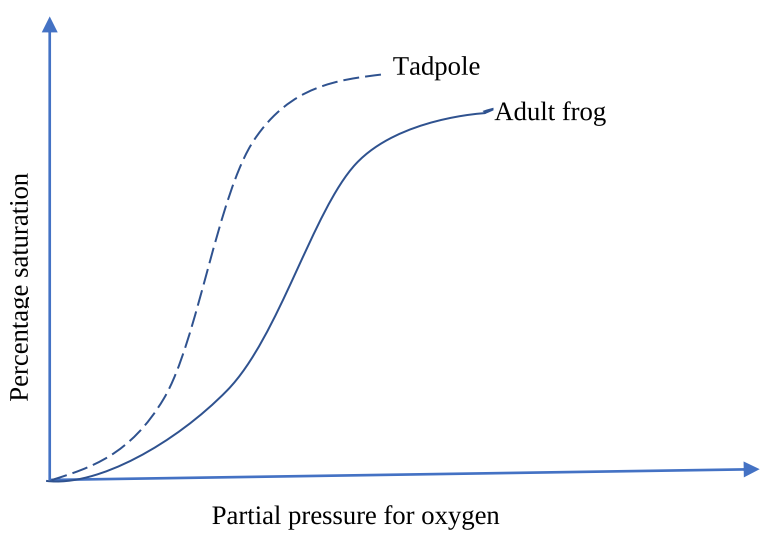


Fig. 7

(a) Explain the relative position of the curve for the tadpole blood and that of an adult frog.

(b) What advantage is the position of the dissociation curve for the tadpole in its environment

(c) How is the skin of an adult frog adapted for gaseous exchange?

Solution

(a) The tadpole curve is to the left adult frog curve. This means that Tadpole blood has higher affinity for oxygen than that of adult frog
This is because affinity allows its haemoglobin to get saturated at low oxygen tension.

(b) Tadpole haemoglobin becomes fully saturated at low environmental partial pressure of oxygen. This allows it to thrive in the low oxygen tension environment.

Tadpole blood releases oxygen quickly to the tissue that are at very low oxygen.

(c) The skin of the frog is moist. Respiratory gases can easily dissolve in the moisture, so enhancing their diffusion across the skin.

The skin of the frog is thin. This reduces the distance across which the gases have to diffuse during gaseous exchange.
It is supplied by a dense network of blood capillaries. This maintains a steep diffusion gradient across the skin and encourages exchange of the gases.

41. Give the meaning of each of the following:

(i) Chloride shift

(ii) Bohr effect.

(b) Explain the effect of each of the following on the oxygen dissociation curve of haemoglobin in mammals

(i) Increase in environmental temperature

(ii) High the carbon dioxide levels in body tissues.

(c) Explain the physiological advantage of a high concentration of myoglobin in skeletal muscles

Solution

(a) (i) Chloride shift is the movement of chloride ions into red blood cells as bicarbonate ions leave during carbon dioxide transport from the tissue by the blood. It helps to restore electro-neutrality within the red blood cells in tissue capillaries when bicarbonates ions diffuse into plasma.

(ii . Bohr effects is a rightward and downward shift of the haemoglobin oxygen dissociation curve that as a result of increased carbon dioxide partial pressure or decrease in blood pH. It has the effect of reducing the affinity of haemoglobin for oxygen

(b) Increase in environment temperature causes a right shift of the oxygen dissociation curve. This is because the bond between oxygen and haemoglobin is thermo-labile and therefore weakens with increase in temperature. Therefore, the haemoglobin becomes less efficient at picking up oxygen but more efficient at releasing it.

(ii. High carbon dioxide levels in the tissues cause a shift of the oxygen dissociating curve to the right.

This is because carbon dioxide reacts with water to form carbonic acid which dissociate of liberate hydrogen ions into plasma. The hydrogen ions stabilize deoxybaemoglobin and therefore encourage the conversion of o xyhaemoglobin to deoxyhaemoglobin, so reducing haemoglobin affinity for oxygen.

(c) Myoglobin has a higher affinity for oxygen compared to haemoglobin. It holds onto its oxygen and only release it when the oxygen partial pressures have become very low. As a result, it acts as an oxygen store, releasing its oxygen to the issue when oxyhaemoglobin becomes depleted (as during exercise)

43. (a) Explain the following

(i) Breathing in pure oxygen at higher pressures than atmospheric is dangerous

(ii) Breathing in air rich in carbon dioxide is dangerous.

(b). Outline three adaptations of animals that live in environments of low oxygen tension

44. (a) Explain the following

(ii) Breathing in pure oxygen at higher pressures than atmospheric is dangerous

(ii) Breathing in air rich in carbon dioxide is dangerous.

(b). Outline three adaptations of animals that live in environments of low oxygen tension

Solution

(a) (i) The tissue metabolizes rapidly at first to keep with the oxygen supply. As oxygen builds up, it inhibits certain enzymes involved in the Krebs cycle, thus interfering with cell respiration. This often leads to muscle twitching followed by impaired vision breathing difficulties. Confusion and lack of coordination and finally convulsion and death.

(i) It increases the acidity of the blood and tissue fluids, inhibiting enzymes and stopping essential metabolic processes.

It also reduces the affinity of haemoglobin for oxygen so that little oxygen is delivered to the tissue from the lungs

Accumulation of carbon dioxide also interferes with respiration at the cellular level by inhibiting respiratory enzymes.

This may eventually cause tissue death as a result of lack of enough oxygen

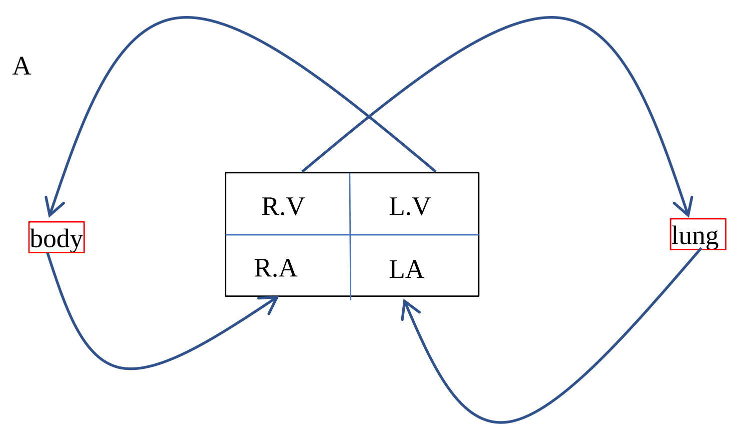
(b) Adaption of animals that live in environments of low oxygen tensions include

- Increased affinity of their haemoglobin for oxygen.
- Increased haemoglobin concentration in their blood.
- Increased number of red blood cells in their blood.

Other

- Increased force and rate of heart contraction.
- Increased rate of breathing.

42. figure 3 shows diagrams of two types of blood circulatory system A and B in animals. The arrows show the direction of blood flow.



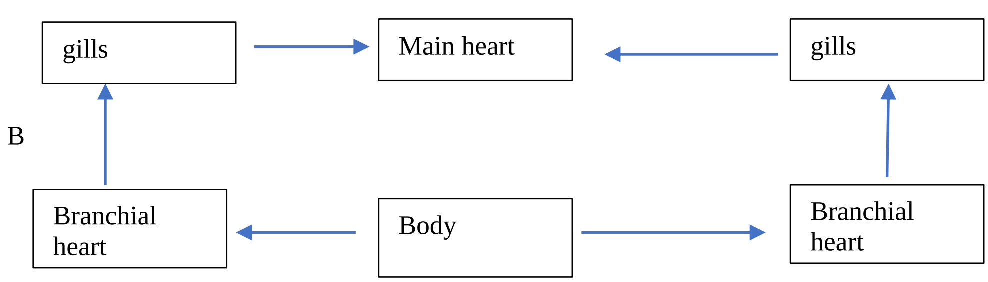


Fig.3

(a) Describe each circulatory system

(i) A

(ii) B

(b) How does each system maintain a high blood pressure?

(i) A

(ii) B

(c) What is the advantage of maintaining a high blood pressure over a fluctuating pressure in a circulatory system of an animal?

Solution

(a) (i) A

- Blood flows from the right atrium into right ventricle, from where it is pumped to the lungs
- It then flows to the left atrium and then into the left ventricle, from where it is pumped to the rest of the body.
- From the body blood returns to the heart through the right atrium
- The cycle repeats.

(ii) B

- From the heart, blood is pumped into the body, from where it flows to the branchial hearts on either side.
- The branchial hearts pump blood to the gills from where it returns to the main heart and the cycle repeats.

(b) (i) A

- In this double circulation system, the contraction of the heart muscles pumps the blood first to the lungs and then to the rest of he body in each circuit of the circulation. This ensures that pressure is restored in the blood after leaving the capillaries.

(iii) B

- The main heart's contraction generates sufficient pressure to push the blood through the vessels in the body
- The branchial hearts then maintain the pressure of the blood by continuing to pump the blood into the gills and back to the main heart.

(c) – high blood pressure helps to propel blood at a high speed along the arteries to the body tissue. This facilitates faster delivery of oxygen and nutrients to the body tissues and removal of waste products from the body.

41. Figure 2 show oxygen dissociation curves for haemoglobin of two animals, X and Y, living in different habitats.

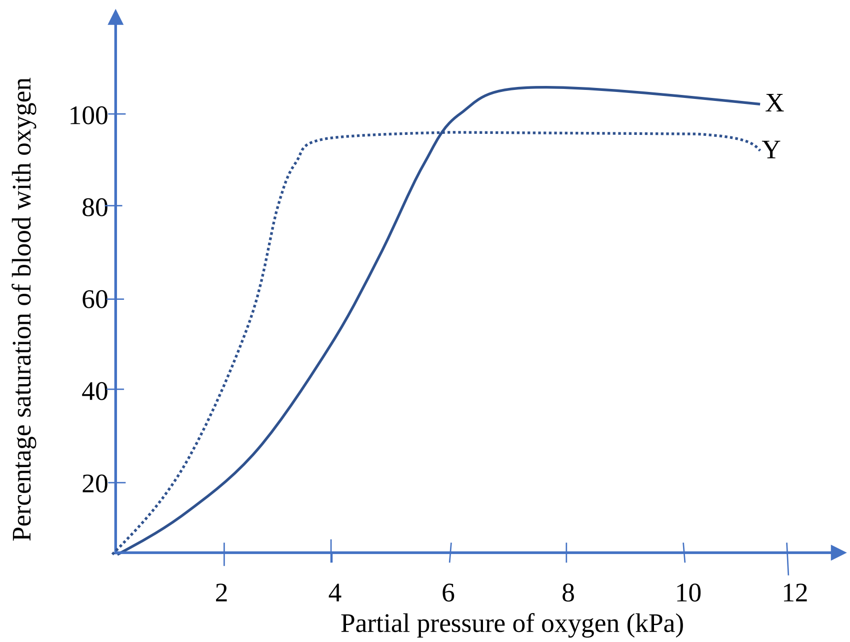


Fig. 1

(a) From the figure, state three differences in the behavior of haemoglobin of the two animals.

(2marks)

(b) (i) Outline the characteristics of the haemoglobin of animals **y**. (3marks)

(ii).From characteristics in (b) (i) suggest the nature of the habitat in which animal **y** lives

(01mark)

(c). Human haemoglobin has a higher affinity for carbon monoxide than oxygen. What is the effect of the fact? (03marks

Solution

(a)

X	**y**
Has a lower affinity for oxygen. Has a lower rate of oxygen saturation Releases oxygen slowly at lower oxygen partial pressures	Has a higher affinity for oxygen Has a higher rate of oxygen saturation Releases oxygen rapidly at lower oxygen partial pressures.

Other:

X	**y**
Becomes fully saturated only at oxygen partial pressures greater than 8kpa Has a higher full saturation capacity (above 80%)	Becomes fully saturated only at oxygen partial pressures greater than 5kpa Has a lower full saturation capacity (about 80%)

(b) (i) Has a higher oxygen affinity

- Has a high rate of oxygen at lower oxygen partial pressures

Others:

- Becomes fully saturated at lower oxygen partial pressures ($\geq$ 5kpa)
- Has a high saturation capacity (over 80%)

(ii). Animal **y** live in a habitat with low oxygen partial pressures such as at high altitude.

(c) In the haemoglobin molecule,, carbon monoxide readily replaces oxygen. It binds irreversibly with haemoglobin molecules and thus reduces oxygen carriage of the blood. As a result, the body tissues are deprived of oxygen leading to tissue death.

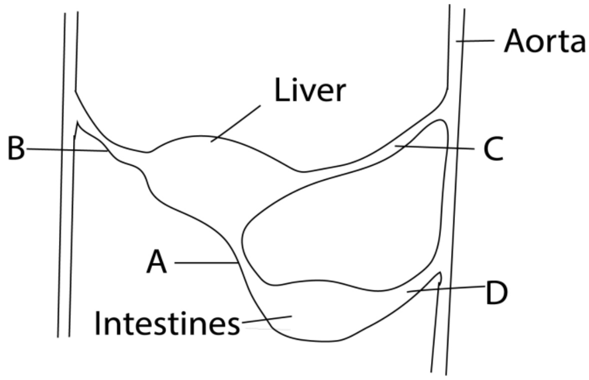
Exercise

1. Which one of the following is correct about the circulation of blood to and from the mammalian heart?
   A. Oxygenated blood from lungs enters through pulmonary artery.
   B. Deoxygenated blood from heart enters lungs through the pulmonary artery.
   C. Oxygenated blood from heart goes to rest of the body through the vena cava.
   D. Deoxygenated blood from body enters heart through pulmonary vessel.
2. Which of the following organs is supplied and drained by a vein?
   A. Stomach
   B. Liver
   C. Kidney
   D. Pancreas
3. Which one of the following is the route a red blood cell takes from the liver to the lung?
   A. Hepatic portal vein, vena cava, pulmonary artery
   B. Hepatic vein, pulmonary vein, pulmonary artery
   C. Hepatic artery, pulmonary artery
   D. Hepatic vein, vena caca, pulmonary artery
4. Which one of the following organ is supplied and drained by a vein?
   A. Stomach
   B. Liver,
   C. kidney
   D. Pancreas
5. In mammalian heart, the thick walls of left ventricle are vital for
   A. Resisting pressure of blood coming into the ventricle
   B. Maintaining the shape of the heart
   C. Producing enough pressure to pump blood to all parts of the body
   D. Resisting back flow of blood from the body
6. Which of the following blood vessel contains blood with the highest amount of oxygen?
   A. Vena cava
   B. Hepatic vein
   C. Pulmonary vein
   D. Hepatic portal vein
7. Which one of the following is not a function of blood?
   A. Regulation of sugar level in blood
   B. Healing of damaged part of the body
   C. Regulation of body temperature
   D. Transportation of wastes
8. Which one of the following contains the lowest concentration of urea?
   A. Hepatic portal vein
   B. Renal artery
   C. Hepatic vein
   D. Renal vein

9. Which one of the following is the correct reason for the thickness of the walls of atria and ventricle?
   A. Atria are thicker because they have to generate higher pressure
   B. Atria are thicker because they have to resist higher pressure
   C. Ventricles are thicker because they have to generate higher pressure
   D. Ventricles are thicker because they have to resist higher pressure.
10. Blood in pulmonary artery is at lower pressure than aorta because in pulmonary circulation
    A. Blood travels a shorter distance
    B. The right ventricle has thinner walls
    C. The vessel carrying blood is smaller
    D. Fewer organs are supplied.
11. Which of the following blood vessel transports blood rich in nutrients?
    A. Pulmonary artery
    B. Hepatic portal vein
    C. Mesenteric artery
    D. Renal vein
12. In human heart, the mixing of oxygenated and deoxygenated blood is prevented by the
    A. Septum
    B. Bicuspid valve
    C. Tricuspid valve
    D. Semilunar valve

Structured questions

13. The figure below is a diagram showing part of mammalian circulation system



(a) Name the blood vessels labeled A, B, C and D.(02 marks)

A: Hepatic portal vein
B. Hepatic vein
C: Heopatic vein
D: mesenteric artery

(b) Using arrows, show on the diagram the direction of blood flow in blood vessels labeled A and B. (01mark)

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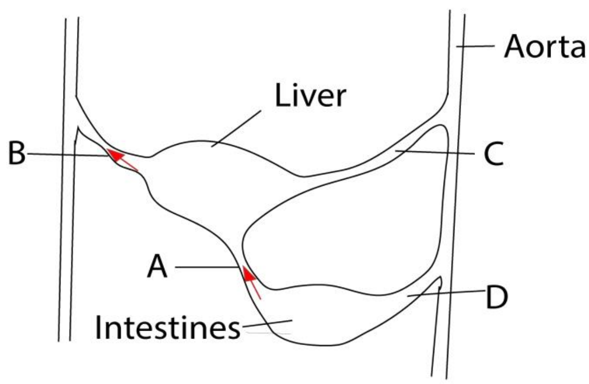

(c) State three differences in composition of blood flowing in A and B. (03marks)
A contains high concentration of food nutrients than B
A contains less waste products than in B
A contains more oxygen than in B

(d) Explain the changes in composition of glucose in A and B (02mark)

The liver remove excess proteins from blood delivered by A to the liver
Deamination produced high waste products in blood vessel B

(e) How is blood vessel A structurally adapted to perform its function?(02marks)
Wide to reduce resistance to blood flow

14. The table below shows the composition of blood od three adult individuals. One lives at high altitude, another is anaemic and the other has an infection. It also shows the average number of each blood component in an adult human. Study the information in the table and answer the questions that fallow.

Components of blood	Person A	Person B	Person C	Average number in adult human
Red blood cells per mm^3	7,500,000	5,000,000	2,000,000	5,000,000
White blood cells per mm^3	6,000	8,000	12,000	5,000 – 10,000
Blood platelets cells per mm^3	250,000	255,000	100,000	250,000

(a) Giving a reason, suggest the person
(i) Who lives at high altitude (03marks)
A has high number of red blood cells
(ii) Who is anemic (03marks)
C has low read blood cells than normal
(iii) Who has infection (03marks)
C has big number of white blood cells
(b) Suggest a likely effect of observed number of blood platelets in person C (02marks)

15. (a) list the substances transported by the blood circulatory system (04marks)
(c) give the importance of transporting each of the substances named in (a) above. (11marks)
16. (a) What is an artery? (1mark)
(b) State three differences between artery and vein. (3marks)
(c) State how arteries and veins are suited for their function
(i) artery (03marks)
(ii) veins (03marks)

Suggested answersc

1	B	3	D	5	C	7	A	9	C	11	B
2	B	4	B	6	C	8	D	10	A	12	A

13 (a) Hepatic portal vein
Hepatic vein
Hepatic artery
Mesenteric artery
(b)