Theme: Transport in plants and animals

S2 New Curriculum Biology-Chapter 7– Transport in Animals

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 conserve water. Example of thick cuticle of insects.
4. Avoids utilization of materials along the way.

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.

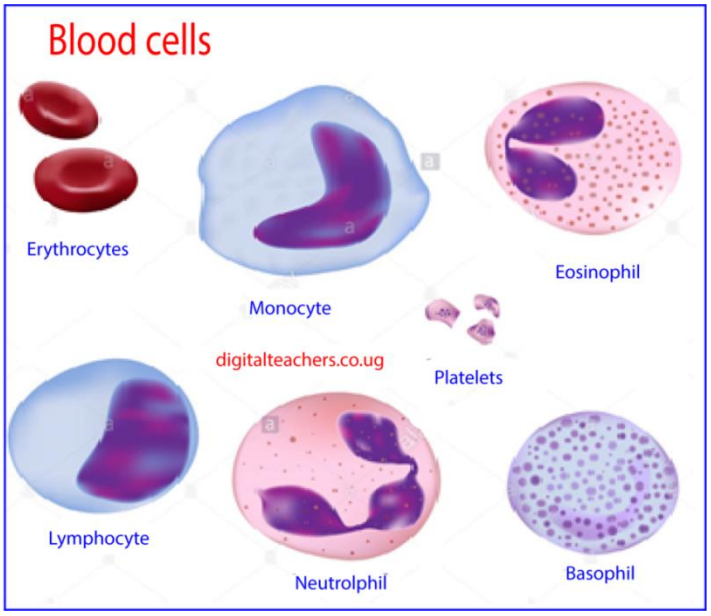
6. Maintenance of a right blood solute potential as a result of plasma proteins activity.

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 and contraction of muscles.
   (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

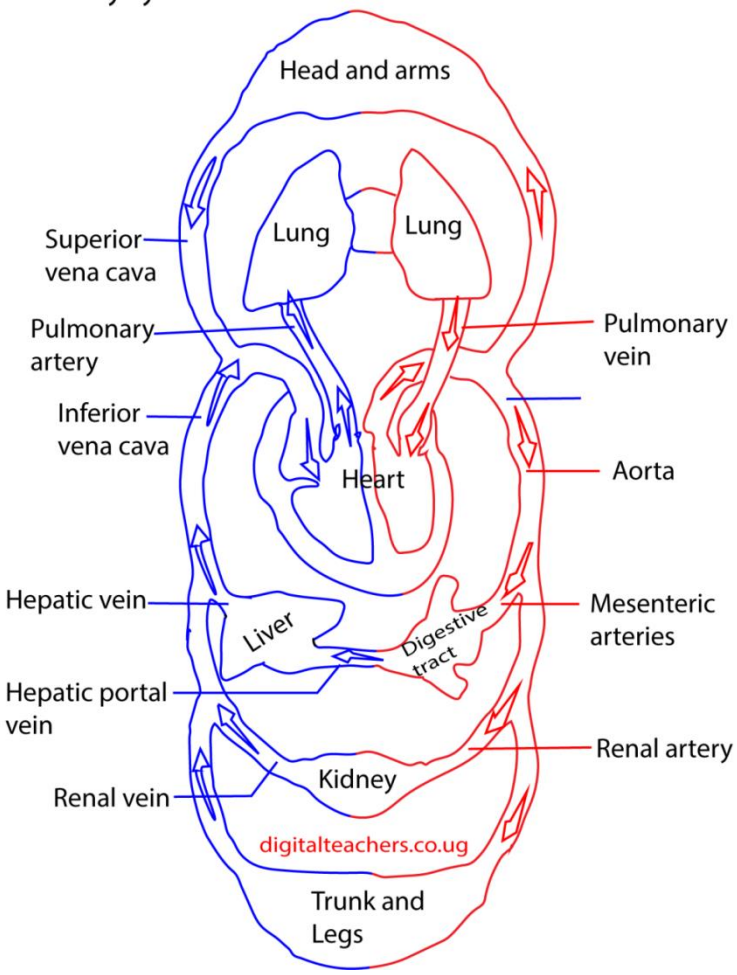
1. They have a biconcave disc shape to increase the surface area for absorption of oxygen.
2. They lack a nucleus, which permits haemoglobin to be packed into the cell.
3. They are small therefore able to squeeze between capillaries
4. They have a thin membrane permitting efficient diffusion of gases (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.

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 vessels in the human Circulatory system

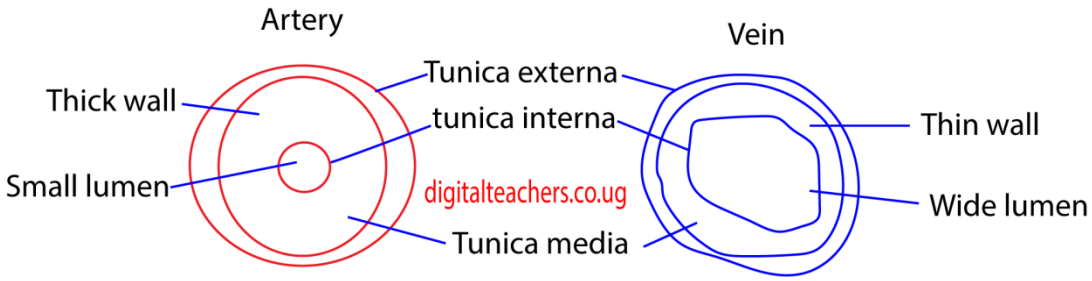
Circulatory system in man



Arties and vein

Arteries transport blood at high pressure to the body from the heart 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
- Ramify the body to increase surface area for exchange

Differences between composition of hepatic vein and hepatic portal vein

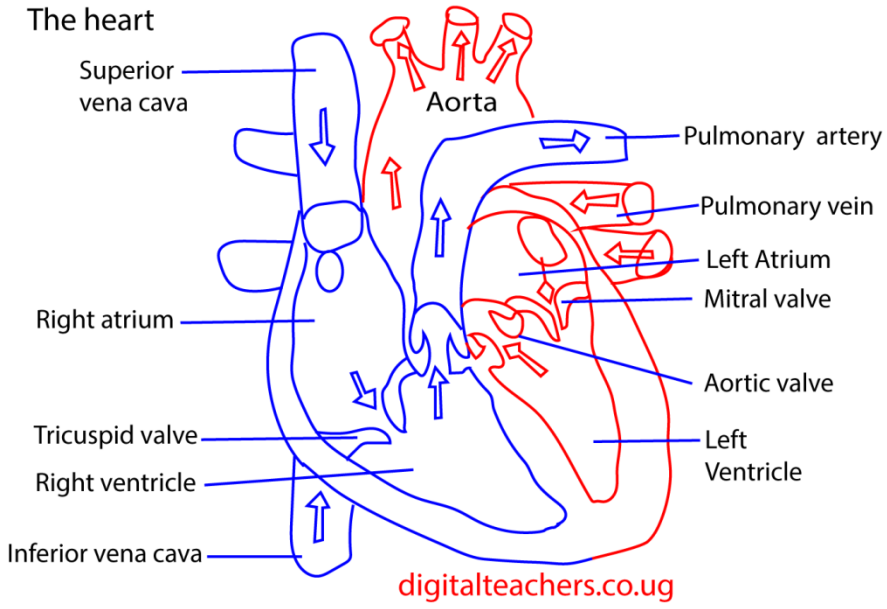
Hepatic portal vein	**Hepatic vein**
Contain more glucose	Contain less glucose
Contain more amino	Contain less amino acid
Less waste metabolic product	More waste metabolic product

Note that

(i) A contain more glucose and amino acids because it carries blood containing absorbed food material from intestines

(ii) Blood vessel B contains less glucose and amino acids because excess amino acid are deaminated while excess glucose is converted to glycogen and stored.

(iii) Blood vessel B contains more waste products because deamination produces ammonia that is converted to urea.



Circulation in the heart

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 mitre.

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**.

Heart diseases

Heart disease/cardiovascular disease is non-communicable disease that affect the proper functioning of the heart.

Causes of heart diseases

Heart disease can have many causes, often linked to lifestyle choices, genetics, or underlying health conditions. Here are some common factors:

- **High blood pressure**: Strains the heart and arteries, increasing the risk of disease.
- **High cholesterol**: Leads to plaque buildup in arteries, restricting blood flow.
- **Smoking**: Damages blood vessels and lowers oxygen levels in the blood.
- **Poor diet**: Eating too much unhealthy food, like processed or fried items, can contribute to heart problems.
- **Lack of exercise**: An inactive lifestyle weakens the heart and circulation.
- **Obesity**: Excess weight increases strain on the heart and can lead to complications.
- **Diabetes**: High blood sugar levels can damage blood vessels over time.
- **Stress**: Long-term stress may contribute to high blood pressure and unhealthy habits.
- **Genetics**: A family history of heart disease can increase your risk.

- **Excessive alcohol consumption**: Weakens the heart muscle and raises blood pressure.

Human blood groups

Antigen is a chemical substance recognized as foreign in the body. Antigens on red blood cells can either be A, B or AB (represented by capital letters)

Antibody is a protective protein produced by the immune system in response to the presence of an antigen. Antibodies destroy or inactivate antigens. Blood with antigen A produces antibody b, blood with antigen B produces antibody a, blood with antigen A and B produces neither antibody while blood with neither antigen produces both antibodies a and b.

Blood groups categorize human blood based on the presence or absence of certain antigens on red blood cells. The main blood group systems are summerized in the table below

Blood group	Antigen present	Antibody produced
A	A	b
B	B	a
AB	A and B	None
O	None	a and b

Blood transfusion

A person that gives blood is referred to as a **donor** while a person that receives blood is called a **recipient**. The table below shows the recipient and respective donor(s).

Recipient	Donors
A	A, O
B	B, O
AB	AB, A, B and O
O	O

The role of blood in the defense of human body

Blood plays a crucial role in defending the body against infections, diseases, and harmful invaders. Here's how it helps:

- **White Blood Cells (WBCs)**: These are the body's primary defense soldiers. They identify and attack bacteria, viruses, and other pathogens.
- **Antibodies**: These are specialized proteins that recognize and neutralize harmful microorganisms, preventing infections.
- **Platelets**: When you get a cut or injury, platelets help form clots to stop bleeding and prevent germs from entering the body.
- **Phagocytosis**: Some white blood cells engulf and digest pathogens, clearing infections before they spread.

- **Inflammatory Response**: Blood carries chemicals that trigger inflammation, which helps isolate infections and heal damaged tissues.
- **Temperature Regulation**: Blood helps regulate body temperature, making conditions less favorable for some harmful microorganisms.
- **Removal of Waste & Toxins**: Blood transports waste and toxins to organs like the liver and kidneys for detoxification.

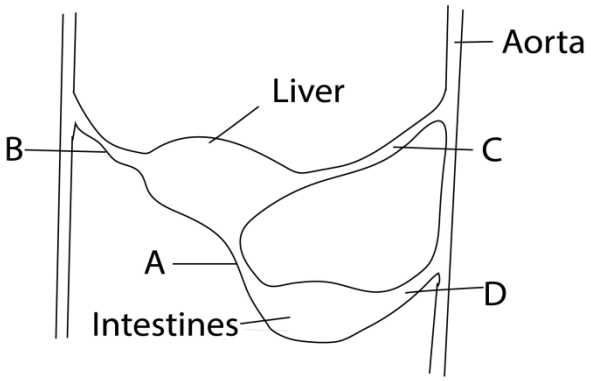
Lymphatic system

The lymphatic system is a vital part of the body's immune defense and fluid balance. It consists of a network of lymph nodes, lymph vessels, and lymphoid organs that work together to protect against infections and diseases. Here's what it does:

- **Fluid balance**: Helps remove excess fluid from tissues and return it to the bloodstream, preventing swelling.
- **Immune function**: Lymph nodes filter harmful substances and contain white blood cells that fight infections.
- **Nutrient transport**: Absorbs fats and fat-soluble vitamins from the digestive system and transports them into the bloodstream.
- **Waste removal**: Clears cellular waste, dead cells, and toxins from the body.
- **Defense against pathogens**: Lymphocytes (a type of white blood cell) attack bacteria, viruses, and other invaders.

Revision exercise

1. 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)
(b) Using arrows, show on the diagram the direction of blood flow in blood vessels labeled A and B. (01mark)
(c) State three differences in composition of blood flowing in A and B. (03marks)
(d) Explain the changes in composition of glucose in A and B (02mark)
(e) How is blood vessel A structurally adapted to perform its function?(02marks)

2. 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)
  (ii) Who is anemic (03marks)
  (iii) Who has infection (03marks)
(b) Suggest a likely effect of observed number of blood platelets in person C (02marks)

3. (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)

4. (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)

5. How does each of the following suit the hearts function(s)
   (a) Septum between heart chambers
   (b) Valves between atria and ventricles
   (c) Thicker wall of the left ventricle

Suggested solution

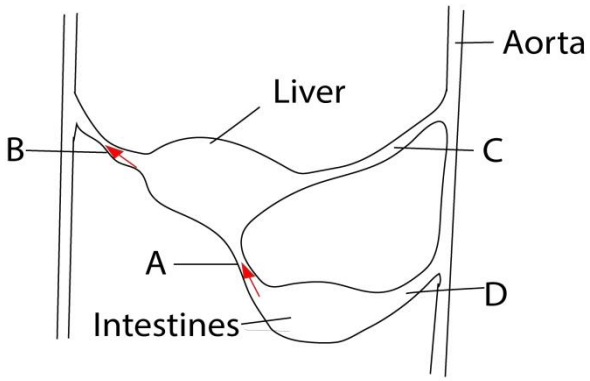
1. (a) Hepatic portal vein

Hepatic vein

Hepatic artery

Mesel

(b)



Differences between composition of A and B

A	B
Contain more glucose	Contain less glucose
Contain more amino	Contain less amino acid
Less waste metabolic product	More waste metabolic product

(d) (i) A contain more glucose and amino acids because it carries blood containing absorbed food material from intestines

(ii) Blood vessel B contains less glucose and amino acids because excess amino acids are deaminated while excess glucose is converted to glycogen and stored.

(iii) Blood vessel B contains more waste products because deamination produces ammonia that is converted to urea.

(e) Adaptation of blood vessel B

- Has broad lumen to allow blood flow at low pressure
- Has thin wall to reduce resistance to blood flow

2. (a) (i) Person A lives at high altitude because has a big number red blood cells to enable him to obtain oxygen at low partial pressure.

(ii) Person C is anaemic because he has low red blood cells

(iii) person C has an infection because he has a big number of white blood cell

(b) Low platelets is cause by
- Medication like antibiotic
- Anaemia
- Diseases like leukaemia
- Heavy alcohol drinking
- Exposure to poisonous substances

3. (a) Substances transported in blood
   - Water
   - Red blood cell
   - White blood cell
   - Nutrients
   - Waste metabolic products
   - hormones

(b) Importance of transporting substance s in the body

(i) water distributes mineral salts

(ii) red blood cells carry oxygen from the lungs to the body

(iii) white blood cells fight germs

(iv) nutrients are distributed to the body cell
(v) waste metabolic products are carried to excretory organs
(vi) hormones are carried for their source to the target organs
(vii) fibrinogen is carried to damaged places where clotting is required

4. (a) artery is a blood vessel that carry blood from the heart

(b) **Differences between arteries and veins**

	Arteries	veins
1	Thick wall	Thin walls
2.	Narrow lumen	Broad lumen
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.

(c) (i) 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.

(ii) Adaptation of veins

-wide lumen to lower resistance to blood flow

-valves allow blood tom flow in one direction

5. (a) Septum prevents mixing of oxygenated and deoxygenated blood
   (b) these valves prevent flow of blood from the atria to the ventricle when the ventricles relax.
   (c) thick wall of the left ventricle generates a strong push of blood to the whole body.