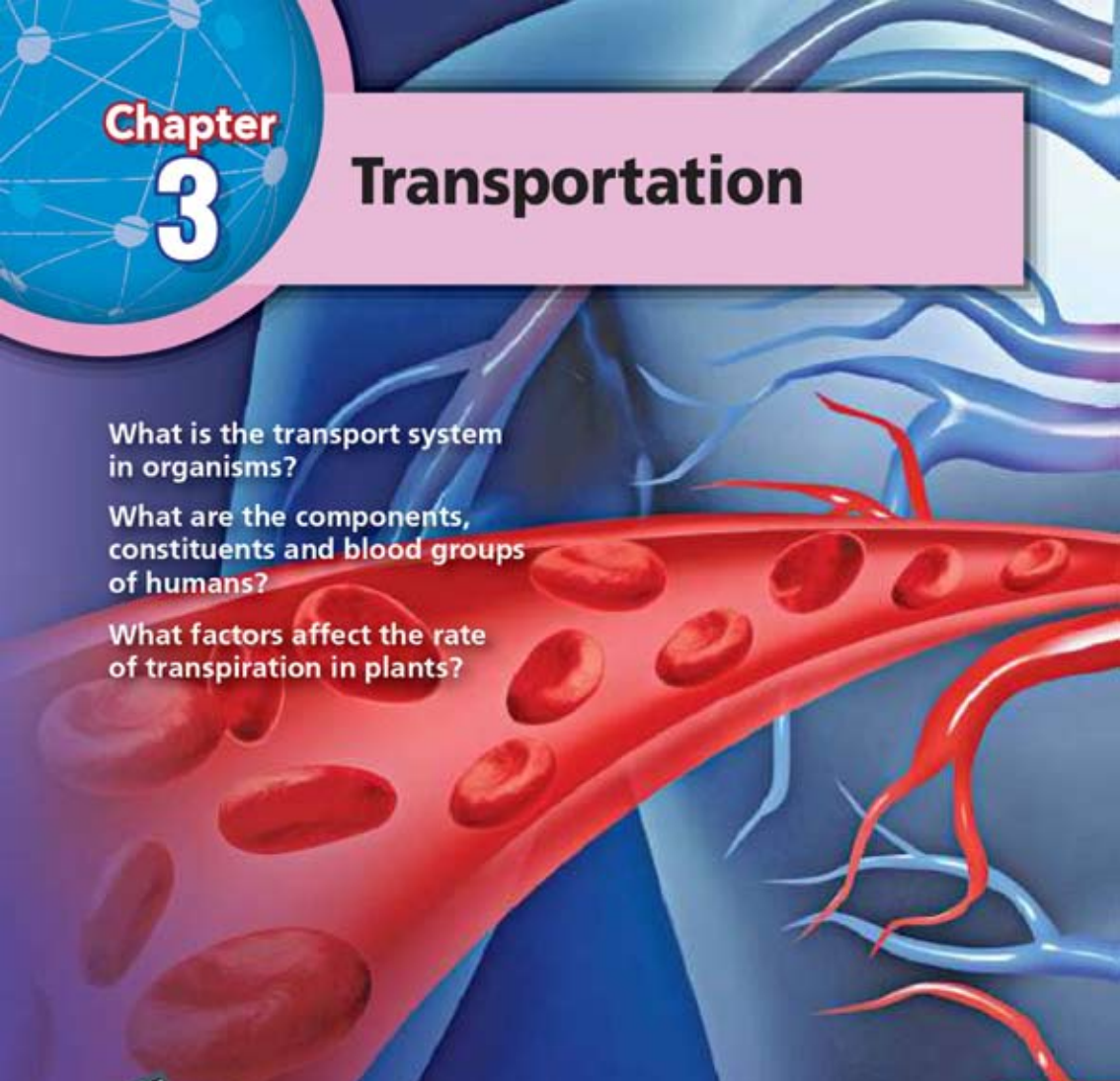
Chapter 3

Transportation



What is the transport system in organisms?

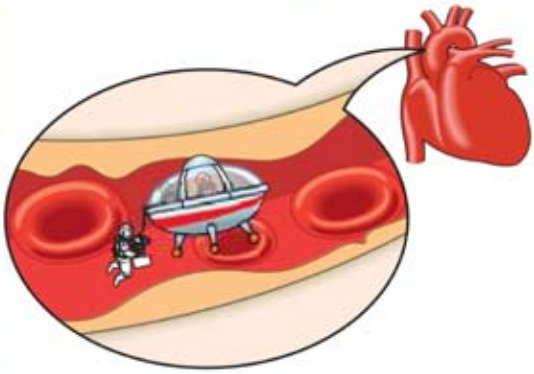
What are the components, constituents and blood groups of humans?

What factors affect the rate of transpiration in plants?

Let's study

- Transport system in organisms
- Blood circulatory system
- Human blood
- Transport system in plants
- Blood circulatory system in animals and transport system in plants

Science Gallery



In 1966, a science fiction film 'Fantastic Voyage' attracted the interest of many viewers including scientists!

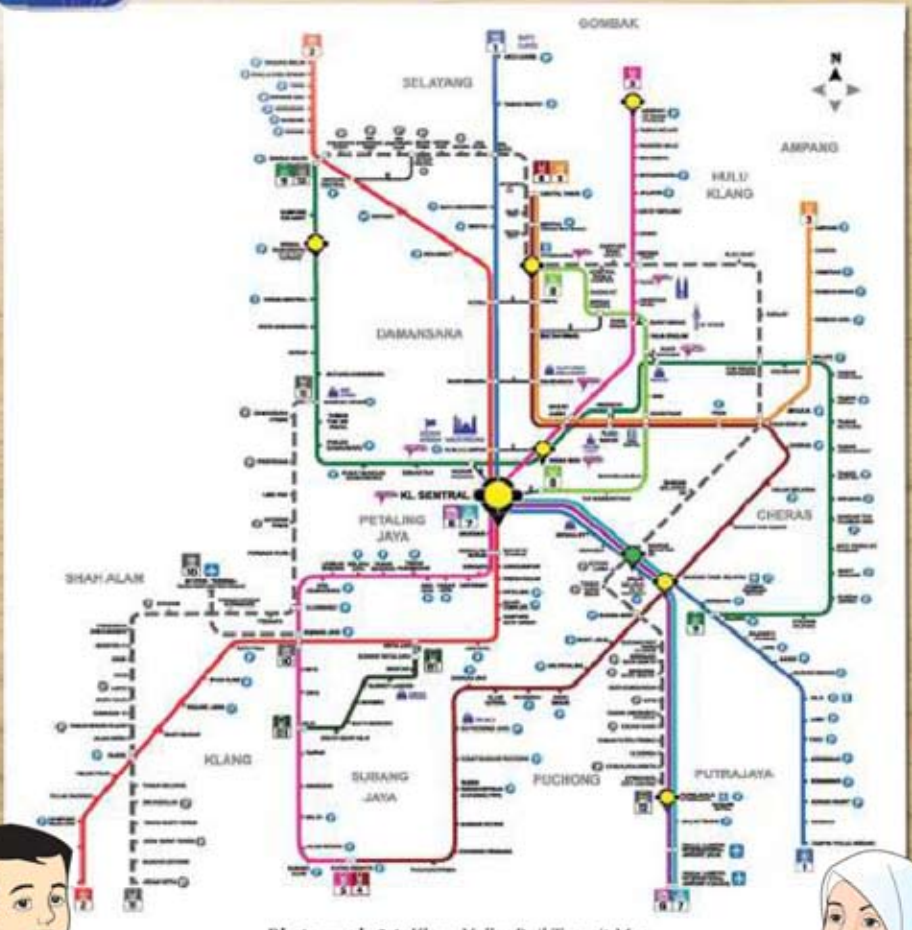
In this film, a team of medical personnel is put into a submarine which is reduced to microscopic size (size of a red blood cell) for an hour using the technological creation of scientist, Jan Benes. This submarine is then injected into the blood circulatory system in Jan Benes's body to eliminate a blood clot in his brain using laser.

The submarine in Jan Benes's blood circulatory system needs to travel through the heart, lungs and other parts of the body before reaching the blood clot in his brain. Can the blood clot be eliminated using laser in one hour? Is there a possibility of this film being classified as a science documentary film in the future? Why?

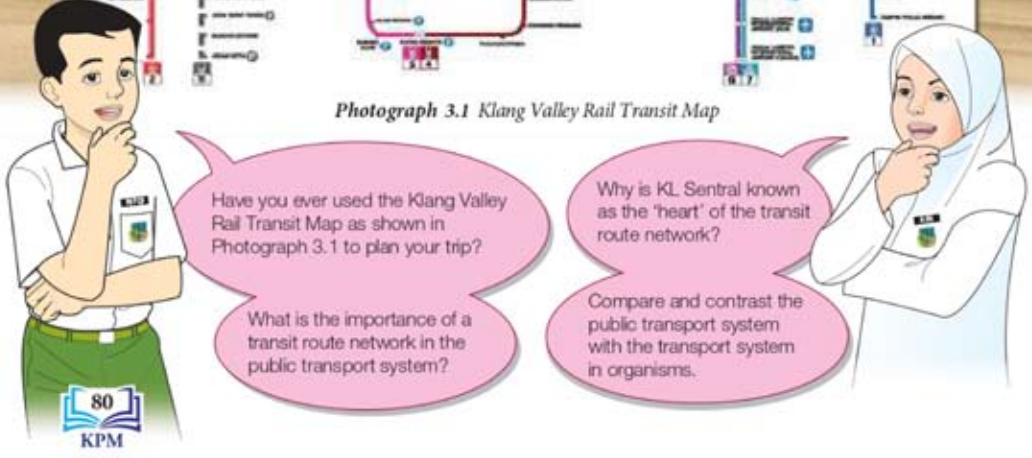
Keywords

- Heart
- Artery
- Vein
- Capillary
- Antigen
- Antibody
- Transpiration
- Guttation
- Xylem
- Phloem

3.1 Transport System in Organisms



Photograph 3.1 *Klang Valley Rail Transit Map*

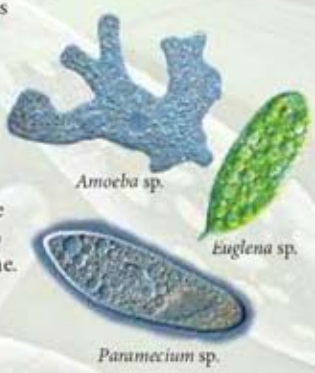


Need for Transport System in Organisms

Every cell needs oxygen for cell respiration and nutrients to obtain energy. At the same time, carbon dioxide and other waste products produced by cells need to be eliminated to the external environment. The process of carrying oxygen, nutrients and other useful substances from the external environment into the cells is through **diffusion.** The process of eliminating waste products from the cells is also through diffusion. What is the system that carries useful substances to all parts of the body of an organism and eliminates waste products from the body?

Transport System in Simple Organisms

Simple organisms such as unicellular organisms (Photograph 3.2) do **not** have a specialised transport system. Substances needed by cells such as oxygen and nutrients enter directly into cells via diffusion through the cell membrane. Waste products such as carbon dioxide are also eliminated from cells to the external environment via diffusion through the cell membrane.



Photograph 3.2 *Examples of unicellular organisms*

Transport System in Complex Organisms

Complex organisms such as humans, vertebrates and multicellular plants have a **specialised transport system** as shown in Figure 3.1.

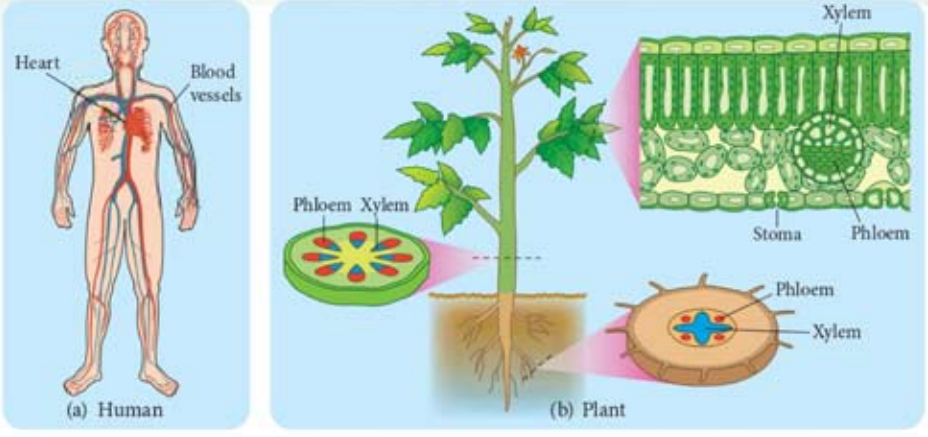


Figure 3.1 *Examples of complex organisms with specialised transport system*

The process of exchange of substances needed by cells and waste products between complex organisms and the external environment (via diffusion) occurs slowly and not comprehensively because complex organisms have a large volume. Therefore, complex organisms need to have a **specialised transport system**. Through this specialised transport system, oxygen and nutrients can be carried to all the body cells in complex organisms and waste products can be eliminated from all the body cells to the external environment.

3.1.1 3.1.2

Importance of the Function of Transport System in Organisms

The importance of the function and impact of transport system in organisms is as shown in Figure 3.2.

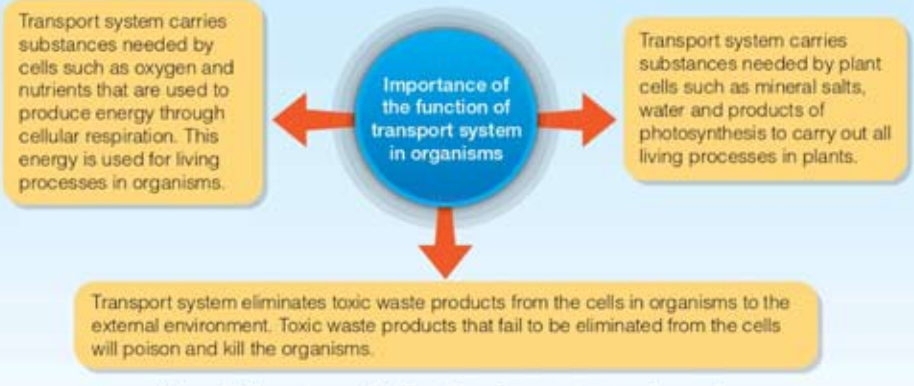


Figure 3.2 *Importance of the function of transport system in organisms*

Activity 3.1

21st Century Skills
- ICS
- Discussion activity

To gather and share information on the need, function, importance and impact of transport system in organisms

Instructions

1. Work in groups.
2. Gather and share information on the following:
   (a) Need for transport system in organisms
   (b) Function of transport system in organisms
   (c) Importance of transport system in organisms
   (d) The impact if transport system cannot function well
3. Discuss the shared information.
4. Present the findings of your group discussion using multimedia presentation such as MS PowerPoint.

Formative Practice 3.1

1. What is the function of the transport system in organisms?
2. State **two** examples of substances needed by cells and **two** examples of waste products that are eliminated from cells.
3. What is the importance of the function of transport system in organisms?
4. Explain the impact on organisms if the transport system in the organisms cannot function well.

3.2 Blood Circulatory System

Blood Circulatory System in Vertebrates

Humans and all vertebrates such as mammals, reptiles, amphibians, birds and fish (complex organisms) have a specialised transport system, that is the **blood circulatory system**. In the blood circulatory system of all vertebrates, blood flows continuously in **blood vessels** to all parts of the body in one complete cycle through the **heart**. However, there are significant **differences** in the blood circulatory system among mammals, reptiles, amphibians, birds and fish. How many times does the blood flow through the heart of mammals, reptiles, amphibians, birds and fish in one complete cycle to all parts of the body? What is the number of atria and ventricles in the heart of mammals, reptiles, amphibians, birds and fish? Carry out Activity 3.2 to find out the differences.

Activity 3.2

21st Century Skills
- CPS
- Discussion activity

To compare and contrast the blood circulatory system in vertebrates

Instructions

1. Carry out active reading to compare and contrast the blood circulatory system in vertebrates such as mammals, reptiles, amphibians, birds and fish as shown in Figures 3.3 and 3.4.

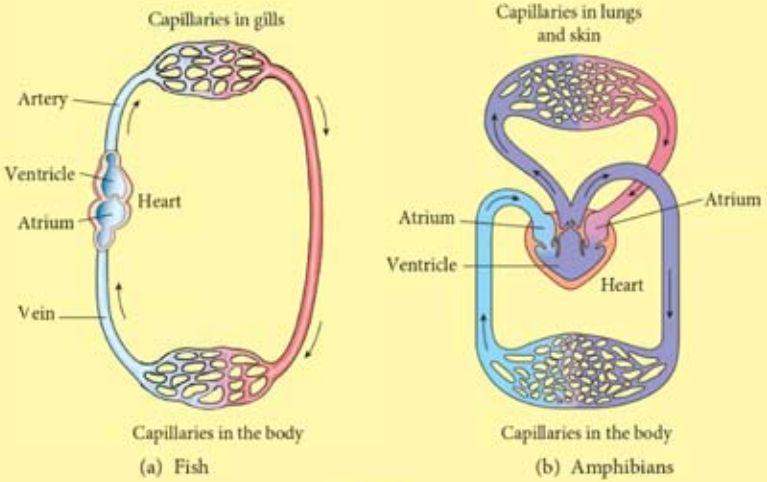


Figure 3.3

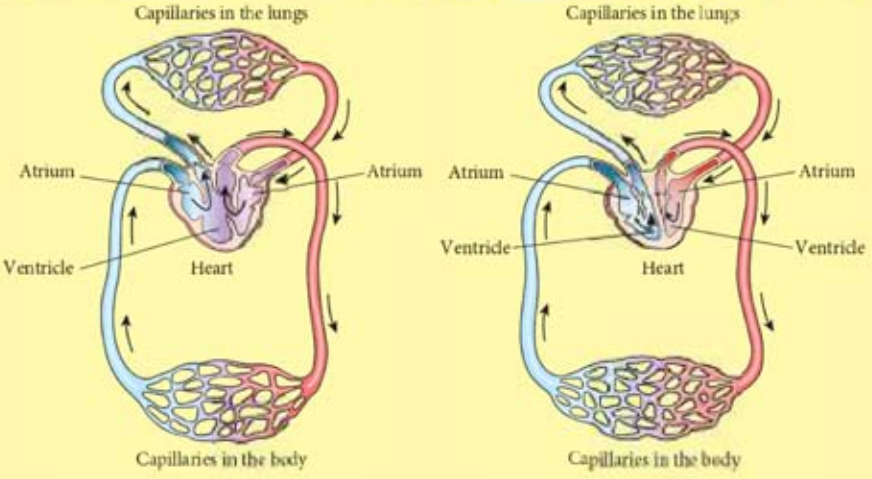


Figure 3.4

2. Complete the chart which shows a comparison of the blood circulatory systems of vertebrates such as mammals, reptiles, amphibians, birds and fish.

Blood circulatory system of vertebrates

Similarities

Made up of a system that allows blood to continuously flow in blood vessels through the heart which pumps blood to the whole body and back to the heart.

Differences

Fish	Amphibians	Reptiles	Mammals and birds

Blood Circulatory System in Humans

The **human blood circulatory system** involves the circulation of blood which is pumped from an organ known as the **heart** to all parts of the body and specialised blood vessels, namely **arteries**, **capillaries** and **veins** as shown in Figure 3.5.

Figure 3.5 Human blood circulatory system

VIDEO

- Human blood circulatory system
- Functions of blood circulatory system

SCAN PAGE

3.2.1 3.2.2

Structure and Functions of the Human Heart

The human heart has **four chambers**, that is **two atria** and **two ventricles** as shown in Figures 3.6 and 3.7.

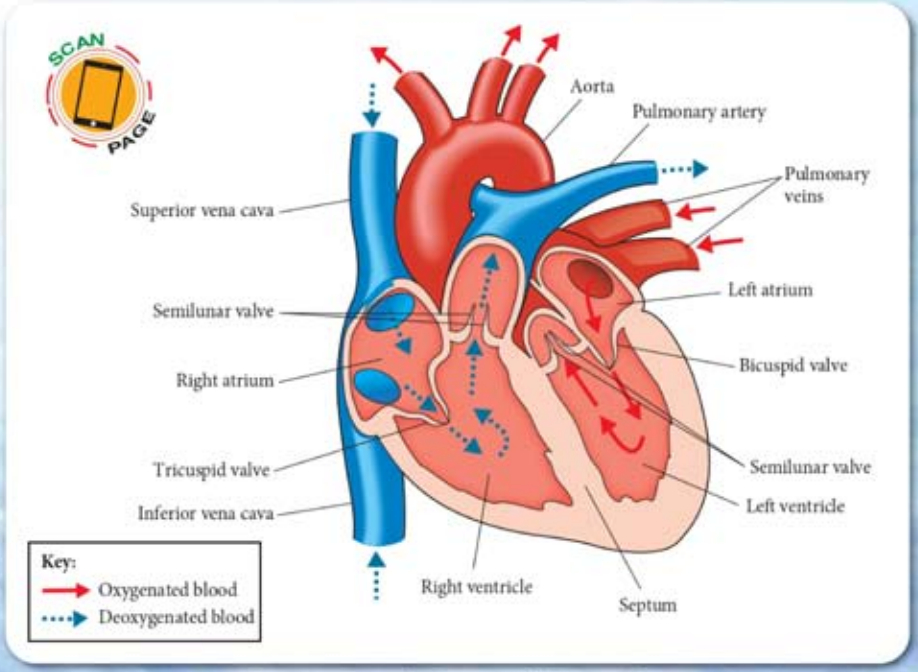


Figure 3.6 Longitudinal section of the human heart

Right atrium has thin muscular **wall**.
Functions:
- **Deoxygenated blood** from the whole body except the lungs enters the **right atrium** through the **superior** and **inferior vena cava**
- When the **right atrium contracts**, **deoxygenated blood** is forced to **flow** into the chamber below it, namely the **right ventricle**

Tricuspid valve
Function:
- Allows the flow of blood in only one direction from the **right atrium** to the **right ventricle**

Right ventricle has thick muscular wall.
Function:
- When the right ventricle contracts, deoxygenated blood is forced to flow out into the **pulmonary artery** to be carried to the **lungs**

SCIENCE INFO

The period of time for blood to make one complete circulation from the heart to all parts of the body including the lungs and back to the heart is approximately 1 minute!

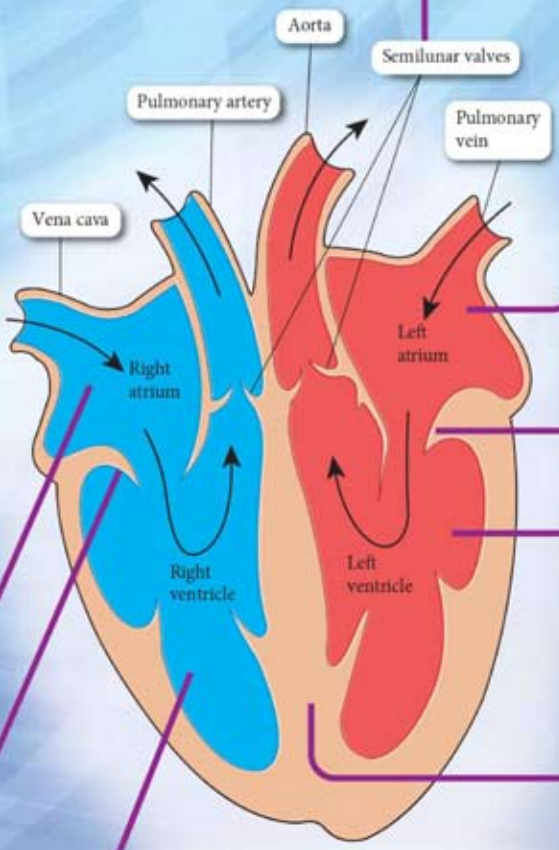


Figure 3.7 Simple structure of the human heart and circulation of blood through the heart

Semilunar valves
Function:
- Semilunar valves at the pulmonary artery and aorta ensure that blood flows only in one direction and not back into the ventricles

Left atrium has thin muscular wall.
Functions:
- **Oxygenated blood** from the **lungs** enters the left atrium through the **pulmonary vein**
- When the left atrium contracts, oxygenated blood is forced to flow into the chamber below it, namely the **left ventricle**

Bicuspid valve
Function:
- Allows the flow of blood in only one direction from the **left atrium** into the **left ventricle**

Left ventricle has the thickest muscular wall.
Function:
- When the left ventricle contracts, oxygenated blood is forced to flow out into the aorta to be carried to all parts of the body except the lungs

Septum is the muscular wall which separates the left side of the heart from the right side of the heart.
Function:
- Prevents oxygenated blood from mixing with deoxygenated blood

Structure and Functions of Main Blood Vessels

There are three human blood vessels, namely **arteries, capillaries** and **veins**. Figure 3.8 shows the relationship between the artery, capillary and vein. Observe the direction of the blood circulation through the artery, capillary and vein as shown in the figure.

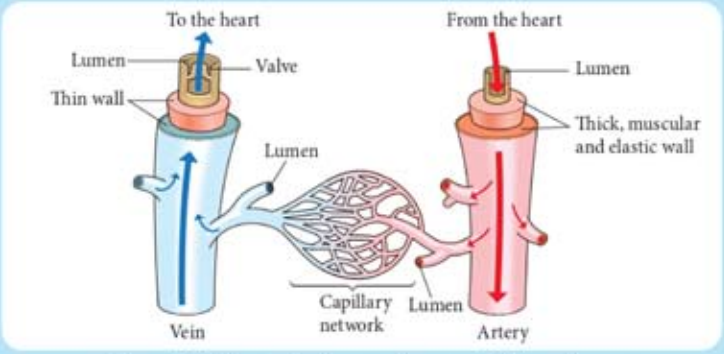
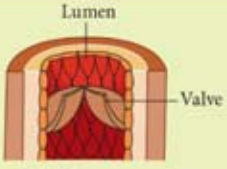
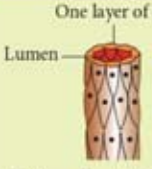
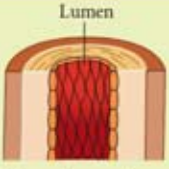


Figure 3.8 *Relationship between the vein, capillary and artery*

Table 3.1 *Structure and functions of the vein, capillary and artery*

Type of blood vessel	Vein	Capillary	Artery
Structure	 • **Thin**, less muscular and less elastic wall to facilitate blood flow under low blood pressure • **Has** valves • **Large** lumen	 • **Thinnest** wall which is one cell thick without any muscle or elastic tissue • **No** valves • **Smallest** lumen	 • **Thick** and muscular wall with a lot of elastic tissues to withstand high blood pressure • **No** valves • **Small** lumen
Functions	• Transports **deoxygenated blood** back to the heart from the whole body except the lungs • Pulmonary vein transports **oxygenated blood** from the lungs to the heart	• Allows the **exchange of gases**, **food** and **waste products** between the blood and body cells via diffusion through the thin wall of the capillary	• Transports **oxygenated blood** from the heart to the whole body except the lungs • Pulmonary artery transports **deoxygenated blood** from the heart to the lungs
Circulation of blood	• **Slow** blood flow under **low** blood pressure • **No** pulse	• **Slow** blood flow under decreasing blood pressure • **No** pulse	• **Rapid** blood flow under **high** blood pressure • Pulse **detected**

'Double' Blood Circulatory System

Humans and other mammals have a 'double' blood circulatory system that is made up of the **pulmonary circulatory system** and **systemic circulatory system**. Carry out active reading to compare and contrast the pulmonary circulatory system and systemic circulatory system as shown in Figure 3.9.

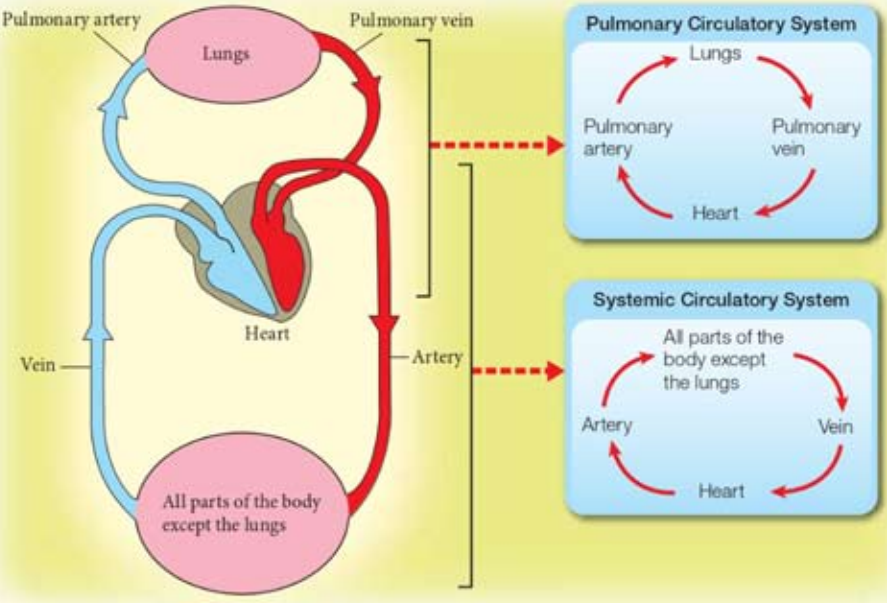


Figure 3.9 *Pulmonary circulatory system and systemic circulatory system*

Activity 3.3

21st Century Skills
- ICS
- Active reading activity

To create a multimedia presentation based on research of a sheep's heart and, explain its structures and functions

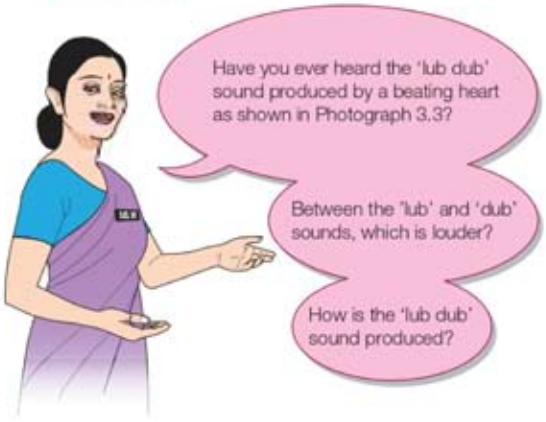
Instructions

1. Work in groups.
2. Each group is required to create a presentation on the research of the heart of a sheep to explain its structures and functions.

Example:
Video on the dissection of a sheep's heart

SCAN PAGE

Heartbeat



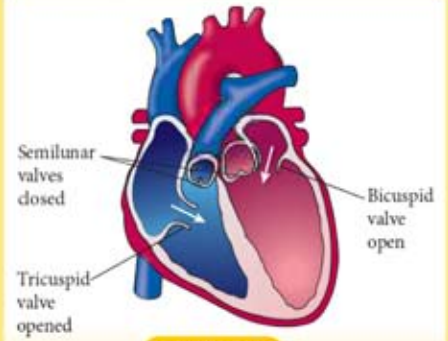
Photograph 3.3 *Hearing the 'lub dub' sound when the heart is beating*

VIDEO

Watch this video to understand the process of diastole and systole

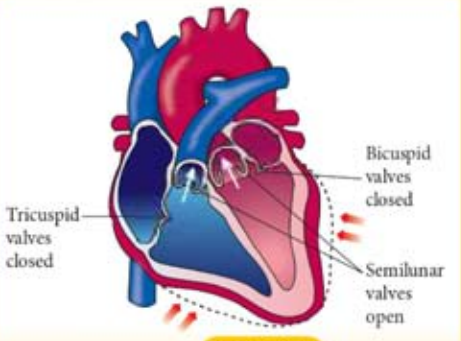
SCAN PAGE

Figure 3.10 shows the sequence of the opening and closing of the valves in the heart during heartbeats.



DIASTOLE

The 'dub' sound is produced by the closure of the semilunar valves at the aorta and pulmonary artery when relaxation of the ventricles occurs. This condition is known as **diastole**. The pressure reading of blood flowing into and filling the heart is called the **diastolic** pressure reading.



SYSTOLE

The 'lub' sound is produced by the closure of the tricuspid and bicuspid valves between the atria and the ventricles when contraction of the ventricles occurs. This condition is known as **systole**. The pressure reading of blood flowing out of the heart is called the **systolic** pressure reading.

Figure 3.10 *Diastole and systole*

Measurement of Blood Pressure

Blood pressure is usually measured using a sphygmomanometer as shown in Photograph 3.4.

Photograph 3.4 *Measuring blood pressure*

i SCIENCE INFO

Taking of diastolic and systolic pressure readings from a sphygmomanometer is based on listening to the sounds produced by the blood circulation when diastole and systole occur. Due to this, the use of sphygmomanometer to take readings of diastolic and systolic pressures is usually done by an experienced doctor.

The systolic pressure reading of a youth is normally 120 mm Hg and the diastolic pressure reading is 75 mm Hg. Hence, this blood pressure reading is normally written as 120/75 mm Hg. Measure and read your blood pressure (systolic and diastolic) using a sphygmomanometer.

BRAIN TEASER

Why is the reading of systolic pressure higher than the reading of diastolic pressure?

Pulse Rate

Photograph 3.5 shows one of the medical examination activities that is normally carried out by a doctor on a patient. What is the quantity measured as shown in the photograph?

Pulse is produced by the contraction and relaxation of the muscular artery wall. Is your pulse rate constant? Give **two** examples of conditions in your daily life that increase the pulse rate. Let us carry out Experiment 3.1 to study the factors that influence the pulse rate.

Photograph 3.5 *Detecting pulse*

Experiment 3.1

Aim
To study the factors that influence the pulse rate

Problem statement
How does the intensity of a physical activity influence the pulse rate?

Hypothesis
The more vigorous a physical activity, the higher the pulse rate.

Variables
(a) manipulated variable : Type of activity
(b) responding variable : Pulse rate
(c) constant variable : Duration of activity

Apparatus
Watch

Procedure
1. Rest for 5 minutes. Then, locate your pulse as shown in Figure 3.11.
2. Count and record the number of pulses over a period of 10 seconds in a table. Calculate the pulse rate in number of pulses per minute.
3. Repeat steps 1 and 2 after carrying out each of the following types of activities over a period of 5 minutes:
   (a) Walking slowly
   (b) Running

Figure 3.11

Type of activity	Number of pulses over a period of 10 seconds	Pulse rate (number of pulses per minute)
Resting		
Walking slowly		
Running		

Conclusion
Is the hypothesis accepted? What is the conclusion of this experiment?

Questions
1. How does the type of activity influence the pulse rate?
2. How is the increase in pulse rate while carrying out vigorous activities related to the rate of oxygen intake and release of carbon dioxide?

Other Factors that Influence the Pulse Rate

Apart from physical activities, other factors which influence the pulse rate are as follows:

Photograph 3.6 *A modern blood pressure and pulse rate measuring device*

A Gender

The average pulse rate of an adult male is between 70 to 72 beats per minute and the average pulse rate of an adult female is between 78 to 82 beats per minute. The difference in pulse rate between males and females is caused by the difference in the size of the heart. The heart of females which is normally of smaller size pumps less blood for each heartbeat and needs to beat at a much higher rate compared to the heart of males.

B Age

Look at Table 3.2. As the age of a person increases, the person's pulse rate becomes lower.

Table 3.2 *Average maximum pulse rate based on age*

Age (years)	Average maximum pulse rate (pulse per minute)
20	200
25	195
30	190
35	185
40	180
45	175
50	170
55	165
60	160
65	155
70	150

(Source: https://healthyforgood.heart.org/move-more/articles/target-heart-rates)

C Body health

The pulse rate of a less healthy individual is normally higher or lower than the normal pulse rate. A pulse rate that is too high or too low is dangerous and can be life-threatening.

Importance of Maintaining a Healthy Heart

The health of a heart should be given attention since its functions are very important in the continuity of human life. How are we able to enhance the knowledge and understanding of the health of the heart among Malaysians? Carry out Activity 3.4.

Activity 3.4

21st Century Skills
- ICS, ISS, CPS, STEM
- Project-based activity

Enhancing the knowledge and understanding of the health of the heart through project-based learning using STEM approach

Aim

To study the relationship between dietary habits and lifestyle with health of the heart among the locals

Materials

Printed materials and the Internet

Instructions

1. Work in groups of five to six.
2. Study the following problem statement:

   Since 2005, heart disease remains as one of the main causes of death among Malaysians. This problem is closely related to their dietary habits and lifestyles.

3. Gather information related to the given problem statement as follows:
   (a) Types of heart diseases
   (b) Causes of heart diseases
   (c) Ways to prevent heart diseases
   (d) Other related matters
4. Discuss the information required to complete a K-W-L Chart as a guide to prepare a questionnaire.
5. The K-W-L Chart is prepared for a "Gallery Walk" session.
6. Prepare a questionnaire related to the topic of the study.
7. Carry out the study (at least 30 respondents) and analyse the data of the study.
8. Present the analysis of each item in the questionnaire using chart papers or MS PowerPoint software.
9. Present the findings of the study in the form of graphs using MS PowerPoint software.

10. After the presentation and discussion sessions, carry out the following activities in groups under the supervision of your teacher:
    (a) Presentation of the findings of your study in the school assembly
    (b) Health talk programme entitled "LET US TAKE CARE OF OUR HEART" as a co-curricular activity
    (c) Poster competition: Care for Our Heart
    (d) Produce an infographics brochure on the health care of the heart related to dietary habits and lifestyles

Note:
What is the K-W-L Chart Strategy?

The K-W-L Chart Strategy is an active reading strategy. It prepares students to predict what is read and is able to get other students to participate in the content of the topic discussed.

K-W-L Chart Strategy		
K - What we know	W - What we want to know	L - What we learn

My Malaysia!

In July 2017, heart specialists at the *Institut Jantung Negara* (IJN) successfully replaced the damaged aorta of a heart patient with synthetic aorta. Gather further information on this at the following website:
http://bt.sasbadi.com/sc3095

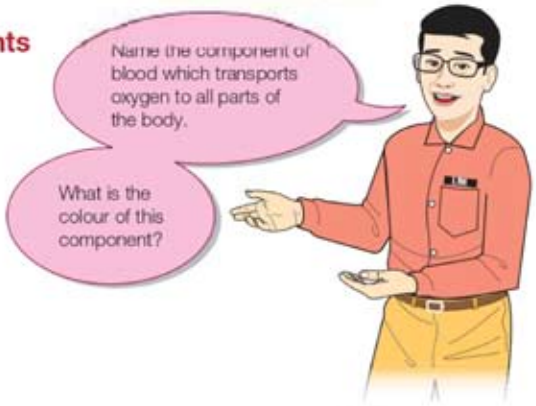
Formative Practice 3.2

1. What is blood circulatory system?
2. Differentiate the functions of the artery, capillary and vein.
3. State **four** factors that influence the pulse rate.
4. What is the importance of taking care of the heart?

3.3 Human Blood

Components and Constituents of Human Blood

Blood transports oxygen and nutrients to the body cells. Blood also transports waste products from the body cells.

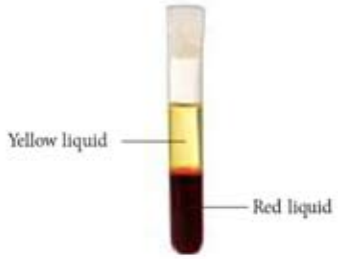


Science Careers

Haematologists are medical specialists who study the components, constituents and diseases related to human blood.

Blood is a type of **mixture** because it can be separated into two components, a **yellow liquid** floating on top of a **red liquid** as shown in Photograph 3.7.

The components of blood are normally separated using the **centrifugal method**. The mixture of blood is rapidly spun in a centrifuge as shown in Photograph 3.8.



Photograph 3.7 *Two components of blood*

Photograph 3.8 *Separation of the components of blood using centrifugal method*

Components of Blood

Blood consists of a suspension of **red blood cells, white blood cells, platelets** and **blood plasma** as shown in Figure 3.12.

Blood plasma is made up of approximately 90% water and 10% dissolved substances flowing to all parts of the body. These dissolved substances include nutrients, carbon dioxide, enzymes, hormones and waste products. Let us carry out Activity 3.5 to study the substances transported by blood.

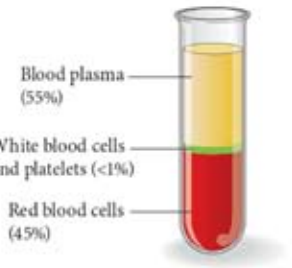


Figure 3.12 *Components of human blood*

Activity 3.5

21st Century Skills
- CPS
- Discussion activity

To study the substances transported by blood

Instructions

1. Work in groups to gather information on the substances transported by blood, namely nutrients, gases, enzymes, hormones and waste products.
2. Carry out active reading on the gathered information.
3. Discuss the information gathered and present the findings of your group's discussion.
4. Complete the following tree map to show the substances transported by blood and the characteristics of the substances.

Substances transported by blood

Nutrients	Gases	Enzymes	Hormones	Waste products

Human Blood Groups

Antigens on Red Blood Cells

Human blood can be classified into four blood groups, namely **A, B, AB** and **O** according to the type of antigen, if any, present on the red blood cells. The type of antigen present on red blood cells is **A antigen** or **B antigen**. The classification of blood groups A, B, AB and O is shown in Figure 3.13.

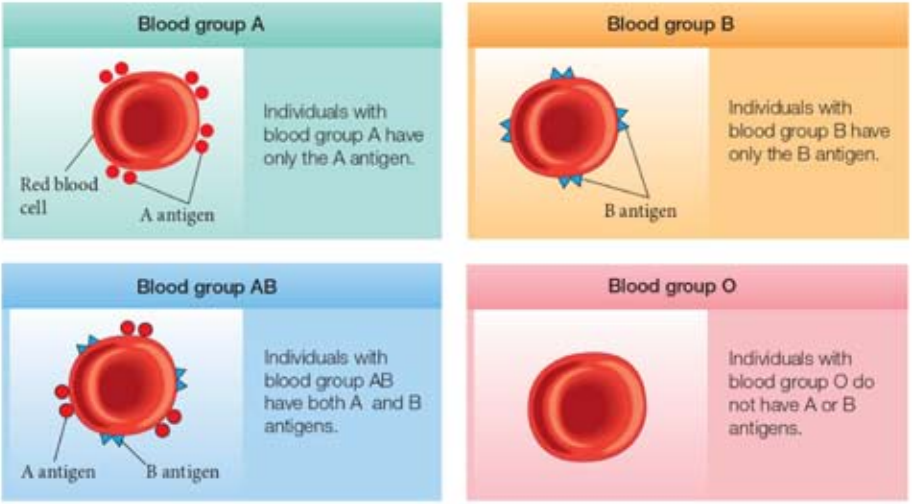


Figure 3.13 *Classification of human blood groups*

Antibodies in Blood Plasma

Blood plasma contains antibodies. The types of antibodies present in blood plasma are **Anti-A** and **Anti-B** antibodies. The types of blood, antigens and antibodies are as shown in Table 3.3.

Table 3.3 *Types of blood, antigens and antibodies*

Type of blood	Types of antigens (On the surface of red blood cells)	Types of antibodies (In blood plasma)
A	A	Anti-B
B	B	Anti-A
AB	A and B	–
O	–	Anti-A and Anti-B

An antibody will attack its corresponding antigen and cause the **coagulation** of blood to occur. This may cause **death**. For example, **Anti-A** antibody will coagulate with A antigen and **Anti-B** antibody will coagulate with B antigen.

Summary based on Table 3.3

- An individual who has **Anti-A antibodies** (type B blood) cannot receive types **A** and **AB** blood because these two blood types contain A antigen.
- An individual who has **Anti-B antibodies** (type A blood) cannot receive types **B** and **AB** blood because these two blood types contain B antigen.
- An individual who has type **AB** blood is free to receive all types of blood because there are no antibodies in his blood (universal recipient).
- On the other hand, an individual who has type **O** blood cannot receive any other blood type because of the presence of Anti-A and Anti-B antibodies in his blood plasma.

Therefore, whether a person can receive blood or not depends on the presence of **antibodies** in his blood plasma.

BRAIN TEASER

Why is an individual who has type O blood known as the universal donor?

Compatibility of Blood Groups of Donors and Recipients

Before blood transfusion, we need to know that the blood groups of the donor and the recipient must be **compatible** as shown in Table 3.4. Otherwise, blood will coagulate. This situation can cause the death of the recipient.

Table 3.4 *Compatibility of blood groups of donors and recipients*

Blood group of donor	Blood group of recipient			
	A	B	AB	O
A	✓	×	✓	×
B	×	✓	✓	×
AB	×	×	✓	×
O	✓	✓	✓	✓

Note: Compatibility of blood for transfusion (✓: compatible ×: not compatible)

Importance of Blood Donation

Take note of the facts shown in Figure 3.14.

Do you agree with the efforts to justify the importance of blood donation in the context of daily life? Carry out project-based learning using the STEM approach on the importance of blood donation through Activity 3.6.

Figure 3.14 *The importance of blood donation*

Activity 3.6

To understand and solve issues related to blood donation in the context of daily life based on projects using the STEM approach

21st Century Skills
- CPS, STEM
- Project-based activity

Instructions

1. Work in groups to study the following statement:

> Every day blood is needed to save lives. Blood is required for surgery, accident victims or to treat patients with leukaemia, haemophilia and other illnesses.

2. Prepare a project using the STEM approach to find creative and innovative solutions for the following issues:
   - Importance of blood donation
   - Criteria to be a blood donor
   - Issues related to blood donation
   - Methods of handling and storing the donated blood
3. Gather the information or existing solutions from the relevant and reliable government or private agencies as follows:

National Blood Centre *http://bt.sasbadi.com/sc3100-1*	Ministry of Health Malaysia *http://bt.sasbadi.com/sc3100-2*	Malaysian Red Crescent *http://bt.sasbadi.com/sc3100-3*

4. Discuss the solutions obtained.
   Present the findings of your group discussion.

SCIENCE INFO

A healthy individual with a mass of more than 45 kg and between 18 to 60 years old can donate blood. A donor can donate up to 0.5 litres of blood at any one time as shown in Photograph 3.9.

When an individual donates blood, the total red blood cells in his body reduces. This forces the bone marrow to produce new cells. The individual will become more energised and able to function better.

Photograph 3.9 *Blood donation campaign*

Formative Practice 3.3

1. State **four** components of human blood.

2. State the largest component of human blood.

3. Mark '✓' for blood groups of donor and recipient that are compatible and '×' for the blood groups of donor and recipient that are not compatible.

Blood group of donor	Blood group of recipient			
	A	B	AB	O
A				
B				
AB				
O				

4. (a) What is the importance of blood donation?
   (b) State **two** examples of diseases that can be treated through blood transfusion.

5. (a) Why is a blood donor with blood group O known as a universal donor?
   (b) Why is a blood recipient with blood group AB known as a universal recipient?
   (c) Why is the blood storage centre known as the blood bank?

6. (a) State **two** public places where people can donate blood.
   (b) Give **one** situation that requires a large amount of donated blood.

7. Figure 1 shows a bag filled with a donor's blood that has been tested.

Figure 1

   (a) Based on Figure 1, state the blood group of the donor.
   (b) Other than blood group, what else is tested in the blood sample of the donor?
   (c) The blood bag contains several chemical substances such as sodium citrate. What is the function of sodium citrate?

3.4 Transport System in Plants

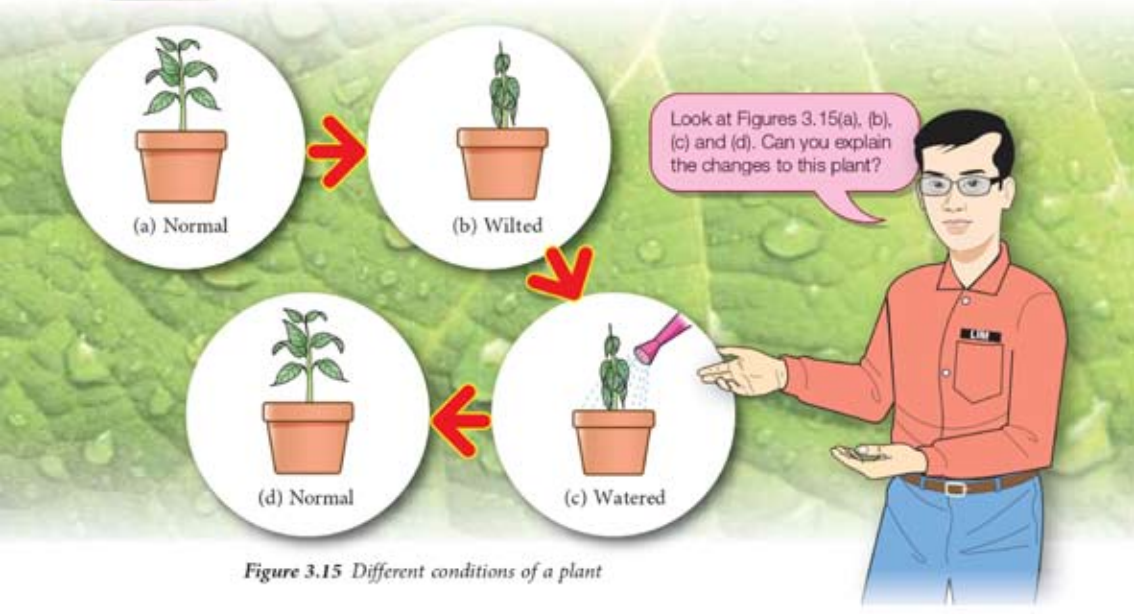


Figure 3.15 *Different conditions of a plant*

Transpiration

Transpiration is a process of **water loss** in the form of water vapour from the surface of leaves to the air through **evaporation**. Study Figure 3.16. **Leaves** are part of a plant where most water loss occurs through transpiration.

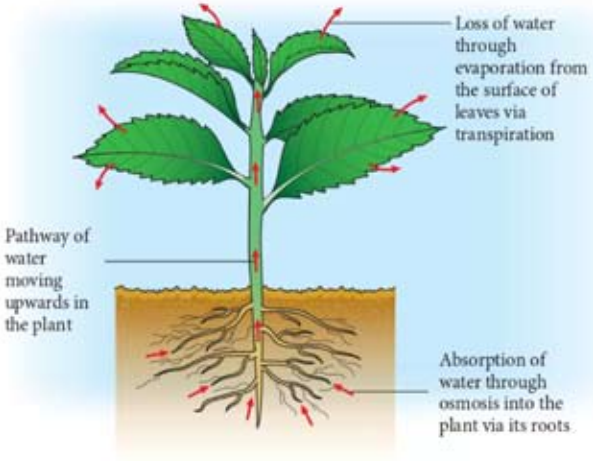


Figure 3.16 *Transpiration and absorption of water in a plant*

Cross Section of a Leaf

The epidermis of a leaf is made up of a single layer of epidermal cells covering both the upper and lower surfaces of the leaf, namely **upper epidermis** and **lower epidermis** as shown in Figure 3.17. Epidermal cells secrete a **waxy cuticle** which covers the outer surface of the leaf to reduce water loss during transpiration.

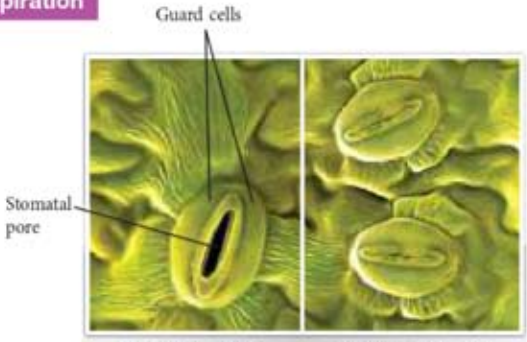
Figure 3.17 Cross section of a leaf

Function of Stoma during Transpiration

Most of the water which is lost during transpiration in plants occurs through the **stomatal pores** found in the epidermis of the leaf as shown in Photograph 3.10.

When photosynthesis takes place during the day, the stoma is usually open as shown in Photograph 3.10(a). What enters the guard cells that causes the stoma to open?

Opening of stoma also causes the plant to lose water through transpiration. Photograph 3.10(b) shows closed stoma to reduce the loss of water through transpiration.



(a) Open stoma (b) Closed stoma

Photograph 3.10 Open and closed stoma

Exudation (Guttation)

Other than water loss from plants through transpiration, water is also lost from plants through **exudation** or **guttation**. Exudation or guttation is the water loss from plants in liquid form through **hydathodes** that are always open at the edges of the leaves. Guttation usually occurs at night or when the air humidity is high. What is the name of the water droplets that come out of leaves as shown in Photograph 3.11? Carry out Activity 3.7 to learn more about transpiration and exudation (guttation).

i SCIENCE INFO

Guttation is different from dew drops. Dew drops are formed from the condensation process of water vapour in the atmosphere into water.

Photograph 3.11
Exudation (guttation)

Activity 3.7

21st Century Skills
- ICS
- Innovation-based activity

To make observations and create presentations to study the processes of transpiration and exudation (guttation) in plants

Instructions
1. Work in groups.
2. Each group is required to create a presentation to study the processes of transpiration and exudation (guttation) in plants.

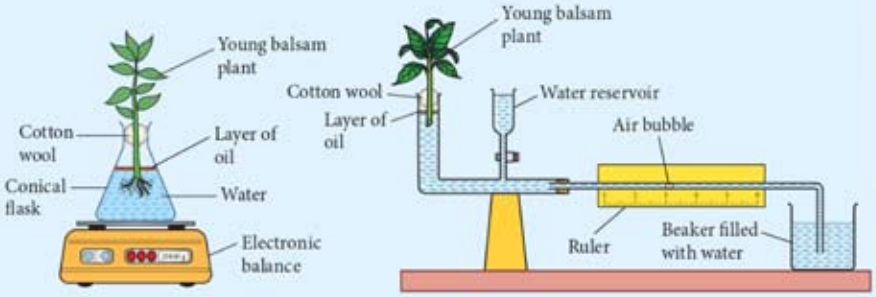
Rate of Transpiration

Transpiration occurs mainly through the stomata. Due to this, the **number of stomata** affects the rate of transpiration in plants. Transpiration is faster if the plant has more stomata. Other factors affecting the rate of transpiration are as shown in Figure 3.18. Carry out Experiments 3.2, 3.3, 3.4 and 3.5 to study the factors affecting the rate of transpiration.

Figure 3.18 Factors affecting the rate of transpiration

SCIENCE INFO

The rate of transpiration of plants is normally estimated using a potometer as shown in Figures (a) and (b) below.



(a) Mass potometer (b) Bubble potometer

Mass potometer measures the rate of transpiration of a plant according to the rate of mass of water absorbed by the plant. **Bubble potometer** measures the rate of transpiration of a plant according to the rate of volume of water absorbed by the plant.

Experiment 3.2

Aim
To study the effect of light intensity on the rate of transpiration

Problem statement
What is the effect of light intensity on the rate of transpiration?

Hypothesis
Increase in light intensity increases the rate of transpiration.

Variables
(a) manipulated variable : Light intensity
(b) responding variable : Rate of transpiration
(c) constant variables : Size and type of plant, air humidity, air movement, temperature and time

Materials
Young balsam plant, water, cotton wool and oil

Apparatus
Electronic balance, conical flask, clock and source of light such as sunlight or lamp

Procedure
1. Set up the apparatus as shown in Figures 3.19 and 3.20.
2. Measure the mass of both apparatus set-ups and record your observation in a table.
3. After 3 hours, measure the mass of both apparatus set-ups once again and record your observation in the table.
4. Calculate the rate of transpiration of the young balsam plant that is exposed to a light source and also the one kept in the dark in a cupboard using the following formula:

$$\text{Rate of transpiration} = \frac{\text{change in the mass of the potometer}}{\text{time taken}}$$

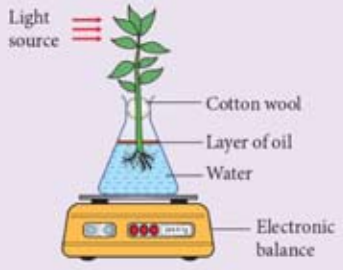


Figure 3.19

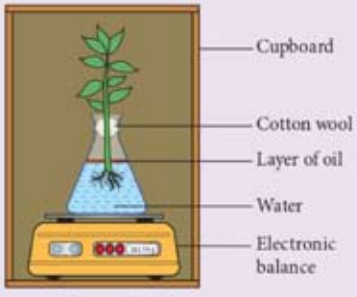


Figure 3.20

Conclusion
Is the hypothesis accepted? What is the conclusion of this experiment?

Experiment 3.3

Aim
To study the effect of air humidity on the rate of transpiration

Problem statement
What is the effect of air humidity on the rate of transpiration?

Hypothesis
Increase in air humidity decreases the rate of transpiration.

Variables
(a) manipulated variable : Air humidity
(b) responding variable : Rate of transpiration
(c) constant variables : Size and type of plant, light intensity, air movement, temperature and time

Materials
Young balsam plant, anhydrous calcium chloride, water, cotton wool and oil

Apparatus
Electronic balance, conical flask, plastic bag, clock and source of light such as sunlight or lamp

Procedure
1. Set up the apparatus as shown in Figures 3.21 and 3.22.
2. Measure the mass of both apparatus set-ups and record your observation in a table.
3. After 3 hours, measure the mass of both apparatus set-ups once again and record your observation in the table.
4. Calculate the rate of transpiration in both apparatus set-ups.

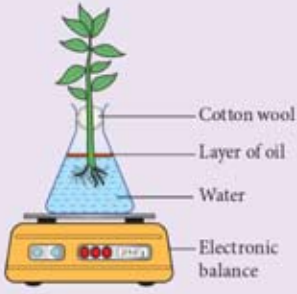


Figure 3.21

Figure 3.22

Conclusion
Is the hypothesis accepted? What is the conclusion of this experiment?

Experiment 3.4

Aim
To study the effect of air movement on the rate of transpiration

Problem statement
What is the effect of air movement on the rate of transpiration?

Hypothesis
Increase in air movement increases the rate of transpiration.

Variables
(a) manipulated variable : Air movement
(b) responding variable : Rate of transpiration
(c) constant variables : Size and type of plant, light intensity, air humidity, temperature and time

Materials
Young balsam plant, water, cotton wool and oil

Apparatus
Electronic balance, fan, conical flask and clock

Procedure
1. Set up the apparatus as shown in Figures 3.23 and 3.24.
2. Measure the mass of both apparatus set-ups and record your observation in a table.
3. After 3 hours, measure the mass of both apparatus set-ups once again and record your observation in the table.
4. Calculate the rate of transpiration in both apparatus set-ups.

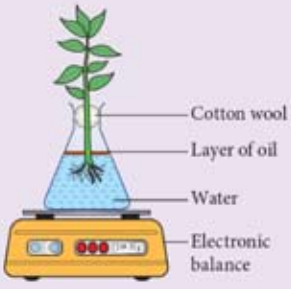


Figure 3.23

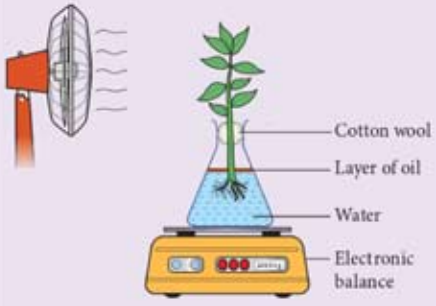


Figure 3.24

Conclusion
Is the hypothesis accepted? What is the conclusion of this experiment?

Experiment 3.5

Aim
To study the effect of temperature on the rate of transpiration

Problem statement
What is the effect of temperature on the rate of transpiration?

Hypothesis
Increase in temperature increases the rate of transpiration.

Variables
(a) manipulated variable : Temperature
(b) responding variable : Rate of transpiration
(c) constant variables : Size and type of plant, light intensity, air humidity, air movement and time

Materials
Young balsam plant, water, cotton wool and oil

Apparatus
Electronic balance, conical flask and clock

Procedure
1. Set up the apparatus as shown in Figures 3.25 and 3.26.
2. Measure the mass of both apparatus set-ups and record your observation in a table.
3. After 3 hours, measure the mass of both apparatus set-ups once again and record your observation in the table.
4. Calculate the rate of transpiration in both apparatus set-ups.

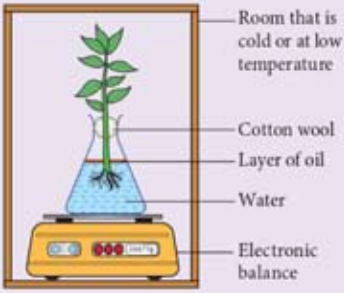


Figure 3.25

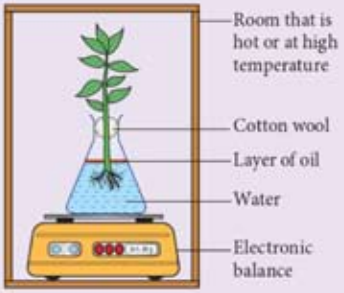
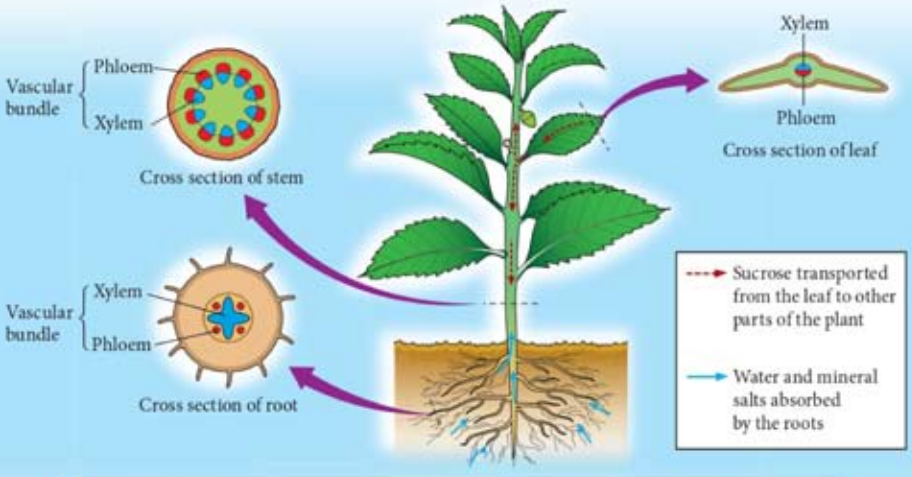


Figure 3.26

Conclusion
Is the hypothesis accepted? What is the conclusion of this experiment?

Structures and Functions of the Components in Vascular Bundles of Plants

Transpiration facilitates the transportation of water and mineral salts in plants. During transpiration, water and dissolved mineral salts diffuse into plants through the roots to the stem and leaves as shown in Figure 3.27.



- **Xylem** transports water and dissolved mineral salts from the roots to the leaves through the stem to carry out photosynthesis and to replace water lost during transpiration.
- **Phloem** transports sucrose produced by leaves during photosynthesis to other parts of the plant.

Figure 3.27 *Transport system in a flowering plant and distribution of vascular bundles in the leaves, stem and roots*

The transport system in flowering plants is made up of two transport tissues, namely **xylem** and **phloem**, which are found in a group of vessels known as **vascular bundles**. Observe the formation pattern of the vascular bundles in the root, stem and leaf as shown in Figure 3.27. Is the formation pattern of vascular bundles in the root, stem and leaf the same or different?

Visit the following websites and watch the video to find out the position and structure of the xylem and phloem in a vascular bundle.

Info 1
http://bt.sasbadi.com/sc3109-1

Info 2
http://bt.sasbadi.com/sc3109-2

Video
SCAN PAGE

Direction of Water and Food in the Transport System of Plants

In Activity 3.8 and Activity 3.9, we will investigate the functions of the xylem and phloem.

Activity 3.8

Inquiry-based activity

Studying the direction of water in plants

Aim: To study the direction of water in a plant

Materials
Balsam plant and eosin solution (red dye)

Apparatus
Conical flask, glass cover, folding knife, microscope and slide

Instructions
1. Wash the roots of the balsam plant carefully with water.
2. Immerse the roots of the balsam plant in a conical flask filled with eosin solution as shown in Figure 3.28.

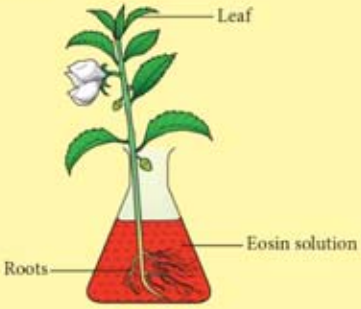


Figure 3.28

Safety Precautions

- Avoid coming in contact with the eosin solution as it will stain your clothes.
- Be careful when using a folding knife.

3. After 30 minutes, make thin cross-sections of the leaf, stem and root of the plant using a folding knife.
4. Examine each of the sections under a microscope.
5. Draw a labelled diagram for each section that has been observed. Identify and label the tissues that have been coloured red by the eosin solution.

Questions
1. Is the eosin solution spread evenly or does it have a specific pattern in the leaf, stem and root of the plant?
2. Name the part which is coloured red in the cross-sections of the leaf, root and stem in this activity.
3. What is the conclusion from this activity?

Activity 3.9

Inquiry-based activity

Studying the direction of food in plants

Aim: To investigate the direction of food in a plant

Material
Woody plant

Apparatus
Scalpel

Safety Precaution
Handle the scalpel with care.

Instructions

1. Choose a healthy branch of a woody plant.
2. Cut a complete ring out of the bark of the plant including the phloem as shown in Figure 3.29.

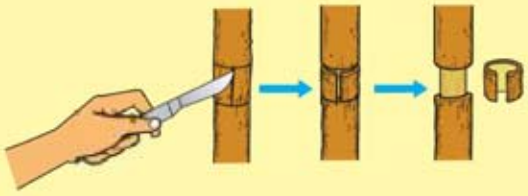


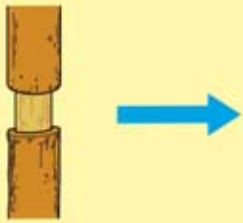
Figure 3.29

Figure 3.30

3. Water the plant every day and expose it to enough light so that the plant can carry out photosynthesis as shown in Figure 3.30.
4. Observe and sketch the changes, if any, in the branch of the woody plant with its bark removed after two to three months.

Questions

1. Sketch the changes in the part of the branch with its bark removed after two to three months.



(a) Beginning of activity

(b) End of activity

2. What is the conclusion from this activity?

Case Study

Based on your understanding of the transport system in plants, discuss examples of hypothetical situations such as when there are no xylem or phloem vessels in the following context:

Propose and discuss:
- ways to transport water and dissolved mineral salts in plants without xylem
- ways to transport sucrose from leaves to all parts of plants without phloem
- adaptations in the transport system to replace xylem and phloem vessels in plants

Formative Practice 3.4

1. What is the meaning of transpiration?
2. Underline the correct answer on the transport system in plants.
   (a) Loss of water from plants through transpiration is in the form of (liquid/vapour) while loss of water through exudation is in the form of (liquid/vapour).
   (b) The tissue that transports water in plants is (phloem/xylem) while the tissue that transports sucrose is (phloem/xylem).
3. State **four** factors that affect the rate of transpiration in plants.
4. Why is dye used to investigate the direction of water in xylem?
5. Figure 1 shows the structure of xylem and phloem in vascular bundles in different parts of a plant.

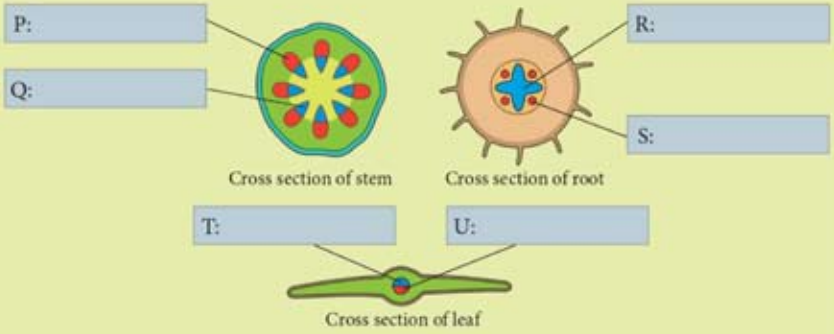


Figure 1

Label P, Q, R, S, T and U using the following words:

Xylem | Phloem

3.5 Blood Circulatory System in Animals and Transport System in Plants

Studies on the blood circulatory system in animals and transport system in plants have made us aware of the uniqueness of circulatory systems to the continuity of life of organisms created by God. What are the similarities and differences between the blood circulatory system in animals and the transport system in plants? Study Figure 3.31.

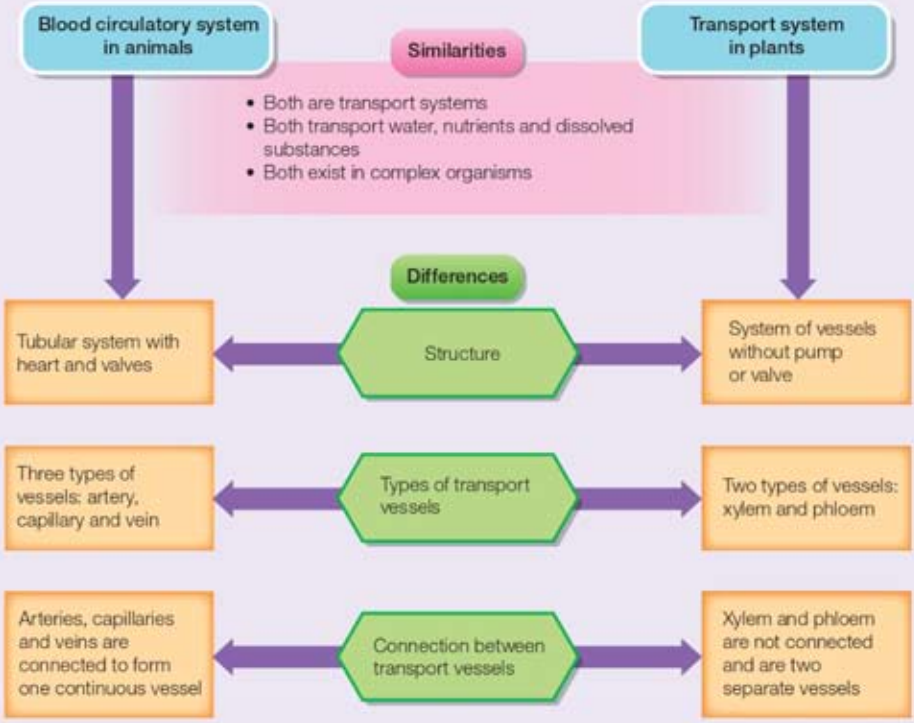
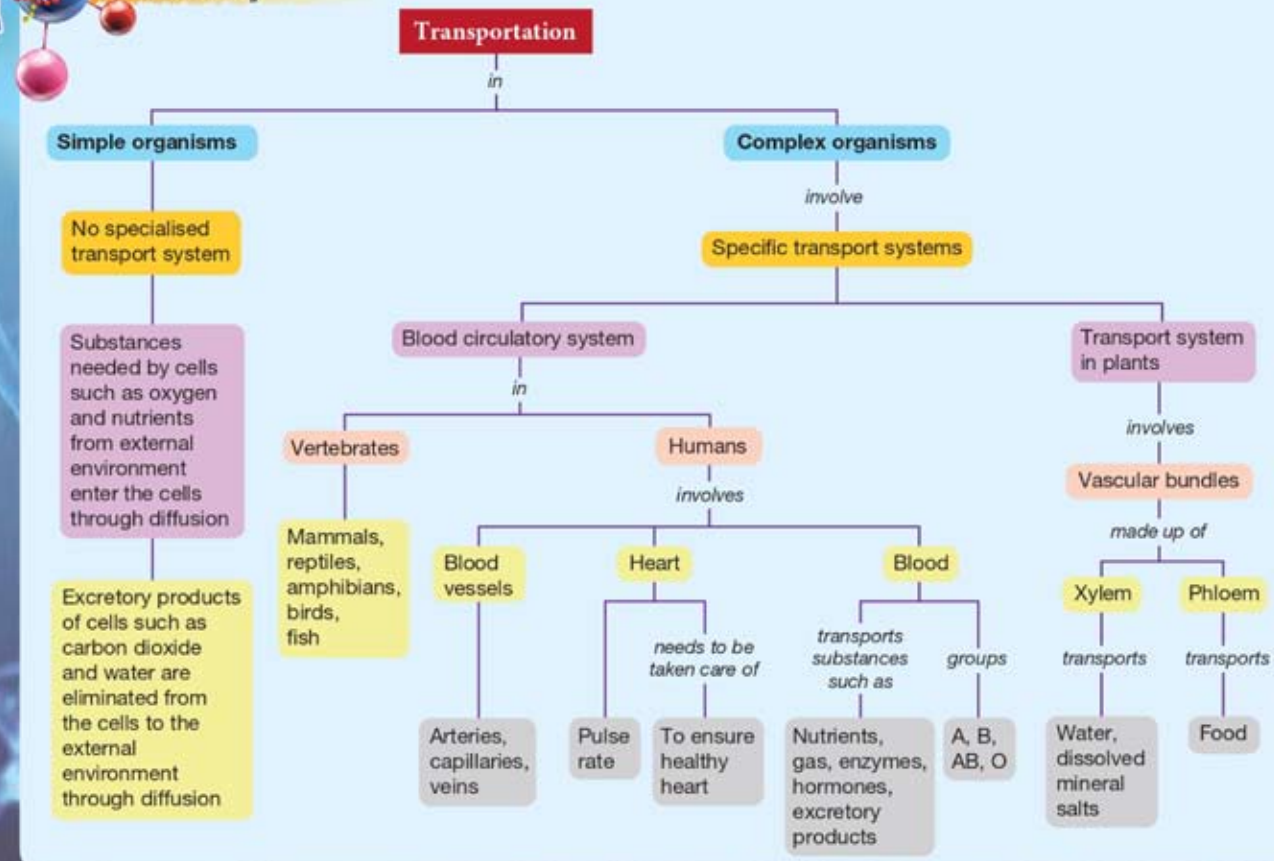


Figure 3.31 *Comparison between blood circulatory system in animals and transport system in plants*

Formative Practice 3.5

1. Give **one** similarity and **one** difference between the blood circulatory system in animals and the transport system in plants.
2. Why should we be thankful for the uniqueness of the circulatory system to the continuity of life of organisms?

Summary


Transportation
in
Simple organisms
No specialised transport system
Substances needed by cells such as oxygen and nutrients from external environment enter the cells through diffusion
Excretory products of cells such as carbon dioxide and water are eliminated from the cells to the external environment through diffusion
Complex organisms
involve
Specific transport systems
Blood circulatory system
in
Vertebrates
Mammals, reptiles, amphibians, birds, fish
Humans
involves
Blood vessels
Arteries, capillaries, veins
Heart
needs to be taken care of
Pulse rate
To ensure healthy heart
Blood
transports substances such as
Nutrients, gas, enzymes, hormones, excretory products
groups
A, B, AB, O
Transport system in plants
involves
Vascular bundles
made up of
Xylem
transports
Water, dissolved mineral salts
Phloem
transports
Food

Self-reflection

After studying this chapter, you are able to:

3.1 Transport System in Organisms

- ☐ Describe the function of transport systems in complex and simple organisms.
- ☐ Compare and contrast the functions of transport systems in complex and simple organisms.
- ☐ Justify the importance of the function of transport system in organisms.

3.2 Blood Circulatory System

- ☐ Generalise the meaning of blood circulatory system in animals.
- ☐ Communicate to explain the structure and functions of a heart and blood vessels in human blood circulatory system.
- ☐ Carry out experiments to study factors that affect pulse rate.
- ☐ Justify the importance of maintaining a heathy heart.

3.3 Human Blood

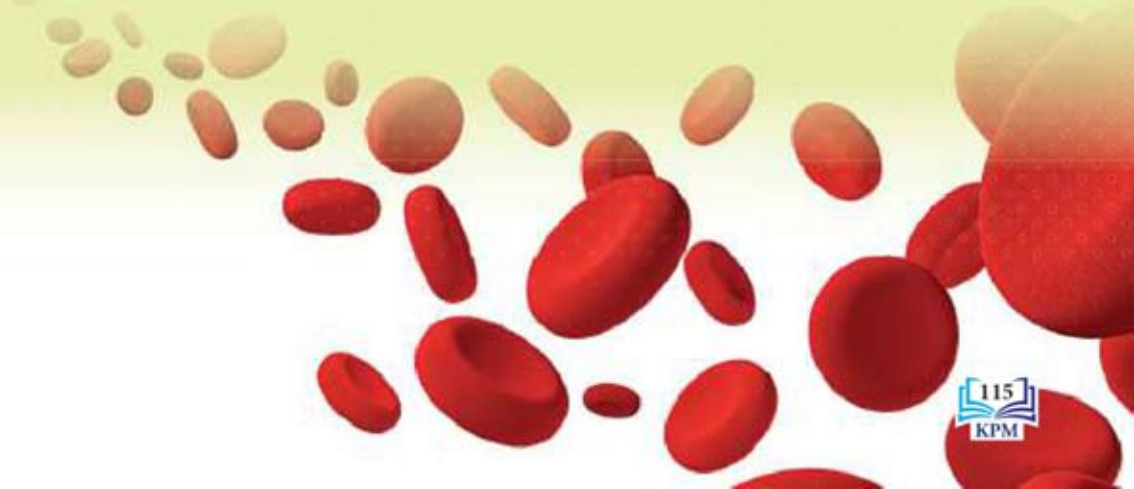
- ☐ Separate the components and constituents of human blood.
- ☐ Identify blood groups and the effects of receiving incompatible blood groups.
- ☐ Communicate the importance of blood donation in context of daily life.

3.4 Transport System in Plants

- ☐ Describe transpiration in plants.
- ☐ Carry out experiments to investigate the factors affecting the rate of transpiration.
- ☐ Differentiate between the structures and functions of components in a vascular bundle of a plant.

3.5 Blood Circulatory System in Animals and Transport System in Plants

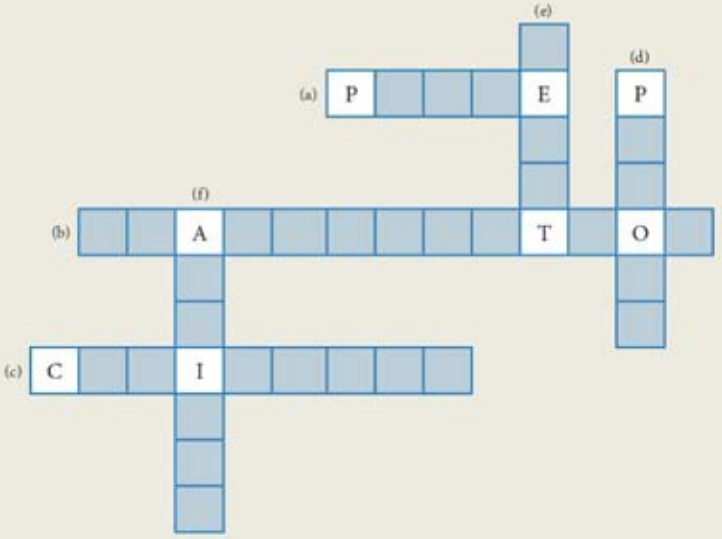
- ☐ Compare blood circulatory system in animals with transport sytem in plants.



Summative Practice 3

Answer the following questions:

1. Solve the crossword puzzle below with the correct answers.



Across

(a) Carrying out vigorous activities increases the rate of _____.
(b) Loss of water from plants occurs through the process of _____.
(c) Blood vessel with the thinnest wall is the _____.

Down

(d) Sucrose is transported by the _____.
(e) The organ which pumps blood is the _____.
(f) Blood group A has one type of _____.

2. Mark '✓' for the correct statement and '×' for the incorrect statement on transport in organisms.

(a) *Amoeba* sp. does not have a specific transport system.	
(b) The function of transport system is only to carry useful substances to all parts of the body of an organism.	
(c) In a systemic circulatory system, blood flows from the heart to the lungs and returns to the heart.	
(d) Coagulation of the blood is an effect from the action of receiving a compatible blood group.	

3. Figure 1 shows three types of blood vessels in the human body.

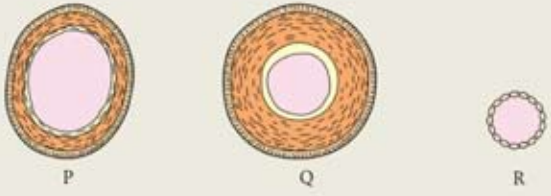


Figure 1

(a) Name the structure in blood vessel P that is not shown in Figure 1.

(b) State the function of blood vessel Q.

(c) Explain the adaptations in the structure of the following blood vessels:
   (i) Blood vessel Q
   (ii) Blood vessel R

4. (a) State **five** substances that are transported in the human body.

(b) State **three** substances that diffuse through the membrane or wall of plant cells and are transported in plants.

(c) Why do plant cells not need a supply of oxygen from outside during the day?

5. (a) Underline the correct answers.
   (i) The ('lub'/'dub') sound is produced by the closure of the valves at the aorta and pulmonary artery.
   (ii) The ('lub'/'dub') sound is produced by the closure of the valves between the atria and ventricles.
   (iii) The pressure reading of blood flowing out of the heart is known as (diastolic/systolic).
   (iv) The pressure reading of blood flowing into and filling the heart is known as (diastolic/systolic).

(b) Between diastolic and systolic pressure readings, which is higher? Explain your answer.

6. (a) Table 1 shows four blood donors from different blood groups.

Table 1

Blood donor	Blood group
Dollah	A
Eric	B
Sita	AB
Roy	O

A road accident victim lost a lot of blood. He is confirmed to have blood from group B.

(i) Which blood donor is suitable to donate blood to the victim?

(ii) Explain the effect to the victim if he receives blood from Sita.

(b) The Red Crescent Society launched a 'Let's Donate Blood' campaign to replenish the blood bank. Three individuals are interested to take part in the campaign. Table 2 shows their age, gender and body mass.

Table 2

Individual	Age (years)	Gender	Body mass (kg)
1	15	Male	62
2	30	Female	70
3	61	Male	66

(i) Based on Table 2, which individual is most suitable to donate blood? Explain your answer.

(ii) What is the special additional condition for blood donors with regard to their suitability to donate blood?

7. Figure 2 shows a cross section of the stem of a plant.

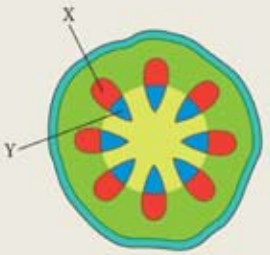


Figure 2

(a) State **one** function of X.

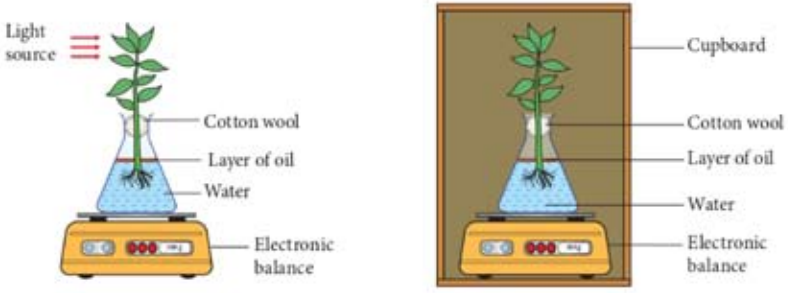
(b) State the structure in the stem of the plant that transports water from the roots to the leaves.

(c) (i) What will happen to the plant if a ring of its bark and X are removed? Explain your answer.

(ii) What will happen to the plant if X and Y are removed?

Focus on HOTS

8. Figure 3 shows the apparatus set-up of an investigation to study the factors that affect the rate of transpiration of a plant and the results after three hours.



Results:

Set	Initial mass (g)	Final mass (g)	Rate of transpiration (g/min)
A	300	246	
B	300	264	

Figure 3

Calculate the rate of transpiration in this investigation.

9. Three students, Badrul, Azizah and Murad carried out a fitness activity to investigate the health of their heart. Table 3 shows the pulse rates for the three of them before and after the fitness activity.

Table 3

Condition	Pulse rate (number of beats per minute)		
	Badrul	Azizah	Murad
Before the activity	63	70	65
Immediately after the activity	130	95	94
15 minutes after the activity	75	71	75

(a) Name the student who is most at risk of having heart disease.
Explain your answer.

(b) Name the student who has the healthiest heart.
Explain your answer.

10. All the members of the Science Club in your school have agreed to carry out a project to plant herbs in school. Herbs that are to be planted will grow well when the rate of transpiration is moderate and the exposure to sunlight is sufficient to carry out photosynthesis. Figure 4 shows three areas:

- Area A, inside a dark laboratory
- Area B, in a shaded bright area
- Area C, in a hot school field under the sun

Figure 4

(a) Based on Figure 4, which is the most suitable area for the project site? Explain your answer.

(b) Construct the most suitable model to make this project a success. The model is a glasshouse or greenhouse in which the air humidity and light intensity can be controlled. The construction of the model requires the use of the following materials: