

6 The Human Circulatory System

The circulatory system, transports blood throughout the body. It is a closed system. The heart pumps blood into the blood vessels. Let us observe the structure of the heart and learn about its functions.



Activity 6.1

You will need: - a model or a diagram of the heart

Method :-

- Observe the model or the diagram of the heart.
- Identify the parts of the heart.
- Use a labelled diagram of a longitudinal section of the heart to identify and study the parts.

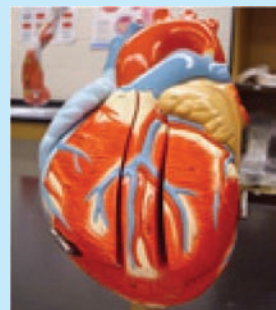


Figure 6.1

6.1 Structure of the human heart

Figure 6.2 shows the longitudinal section of human heart.

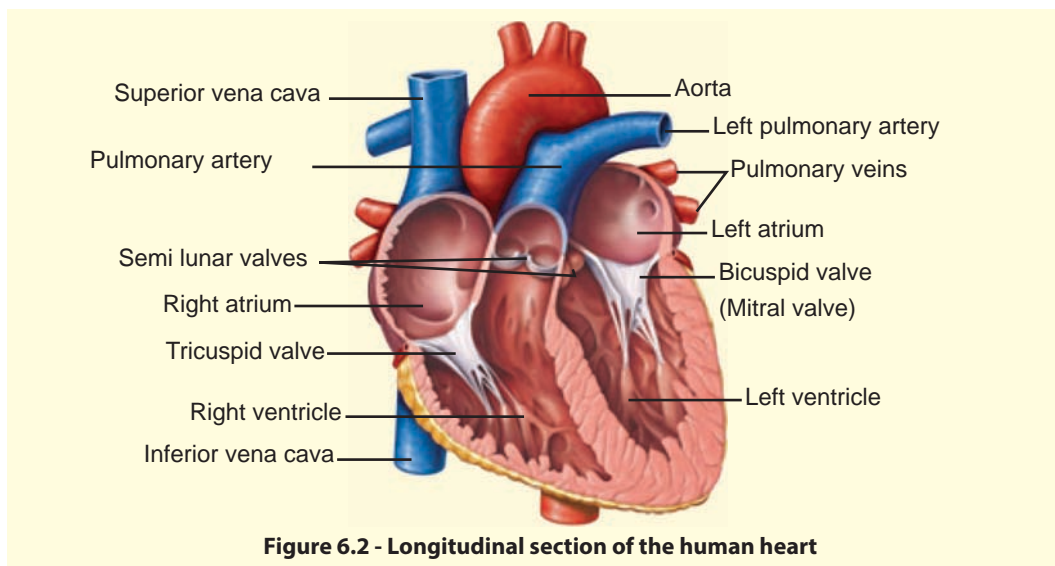


Figure 6.2 - Longitudinal section of the human heart

- The heart has four chambers. The upper chambers are called atria and the lower chambers are called ventricles.
 - ★ Left atrium
 - ★ Right atrium
 - ★ Left ventricle
 - ★ Right ventricle
- There are two valves between the atria and ventricles.
 - ★ Bicuspid valve is in between the left atrium and left ventricle.
 - ★ Tricuspid valve is in between the right atrium and right ventricle.
- There are two main arteries connected to the ventricles.
 - ★ Aorta starts from the left ventricle.
 - ★ Pulmonary artery starts from the right ventricle.
- There are semi lunar valves at the starting points of the main arteries.
 - ★ Aortic semi lunar valve is at the starting point of the aorta.
 - ★ Pulmonary semi lunar valve is at the starting point of the pulmonary artery.'
- Main veins are connected to the atria.
 - ★ The superior vena cava and inferior vena cava open to the right atrium.
 - ★ Left and right pulmonary veins open to the left atrium.



Assignment 6.1

- Construct a model of the heart to show the structure of the heart.

6.2 Arteries, veins and capillaries

The blood vessels that take blood away from the heart are known as arteries while the vessels that take the blood towards the heart are known as veins. Aorta (main arteries) starting from the heart divide into branches.

- The pulmonary artery which starts from the heart transport blood to lungs. Aorta supply blood to the other organs. Within an organ an artery further divides into arterioles and then into capillaries.
- The capillaries join together to form venules and venules join together to form veins.
- Pulmonary veins starting from the lungs take the blood to left atrium.
- Veins from the organs above the heart join the superior vena cava and veins from the organs below the heart join the inferior vena cava. Both the superior and inferior vena cava open into the right atrium.

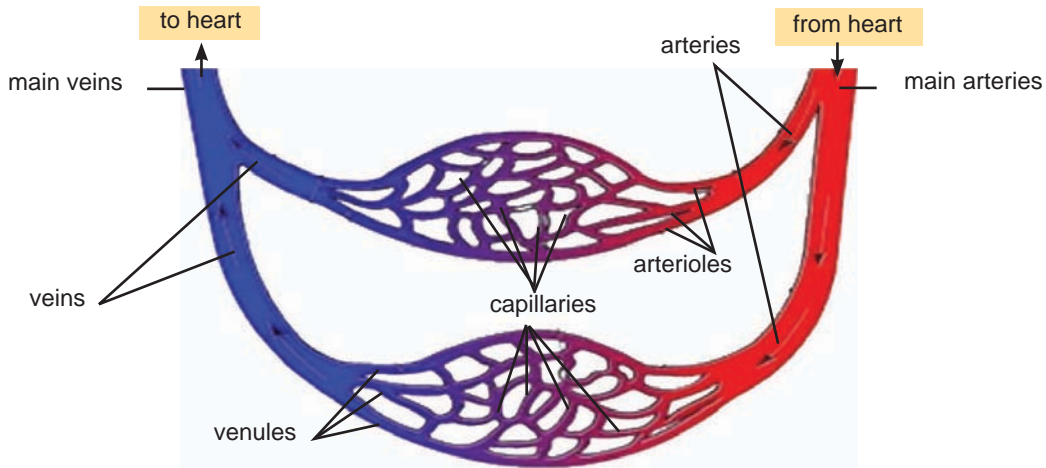


Figure 6.3 - Blood circulation in arteries, veins and capillaries

The artery walls are thick and elastic. So, it can withstand the high pressure of the blood being pumped directly from the heart.

Veins collect blood from the capillaries in the body organs and transport to the heart. The pressure of blood, that flows inside the veins are relatively low. Hence, the walls of veins are thin and less elastic. The valves are open towards the heart to prevent the back flow (figure 6.4 b).

Walls of the capillaries consists of a single cell layer. As they spread among the cells the nutrients and gases in blood diffuse into the cells and the waste matter in the cells diffuse into the blood capillaries (figure 6.4).

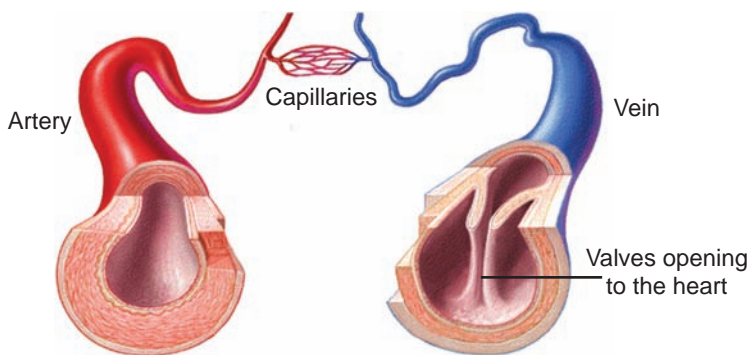


Figure 6.4 - Structure of arteries, veins and capillaries



Activity 6.2

Compare the structural and functional characteristics of arteries, veins and capillaries of the blood circulatory system.

6.3 Components of blood and their functions

Although you see blood as a red fluid, only 55% of its value is in liquid form. This liquid part is called as the plasma. The other 45% of its volume consists of corpuscles which is in solid form.

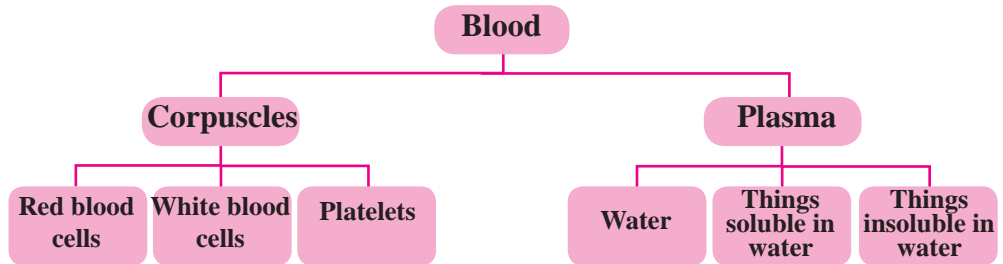


Figure 6.5

A microscopic observation of a blood sample shows three types of corpuscles.

- Red blood cells/ erythrocytes
- White blood cells/ leukocytes
- Platelets

Erythrocytes and leukocytes are cells while the platelets are cell fragments.

Functions of blood

Red blood cells/ erythrocytes

Red blood cells contain a red pigment which is called haemoglobin. Haemoglobin carries oxygen from lungs to the body cells and also gives blood its red colour.

White blood cells/ leukocytes

White blood cells defend the body by destroying pathogens and producing antibodies. White blood cells are categorized into neutrophils, eosinophils, basophils, lymphocytes and monocytes.

Platelets

Platelets help in the clotting process of blood at a bleeding site. Some virus infections cause a rapid decline in a platelet percentage. e.g. Dengue, Leptospirosis

Plasma

The main function of the plasma is transporting substances dissolved in it.

Some examples are given below;

- It transports the digestive products, minerals and vitamins to the cells.
- It transports the excretory products during biochemical reactions within the cells to the excretory organs.
- Plasma transports hormones, proteins, enzymes and gases to the relevant parts of the body.

6.4 Blood transfusion

The transfer of blood from one individual to another is known as **blood transfusion**. The person who donates blood is called the **donor** and the person who receives is called the **recipient**. It is not possible for blood transfusion between any of two people.

For a transfusion to take place compatibility of the blood group and the Rhesus factor between the donor and the recipient is compulsory.

Compatibility of blood group

There are four blood groups A, B, AB and O depending on the protein components in blood cells.

Compatibility of blood groups in transfusion is represented in the table 6.1. (✓ represent positive compatibility of blood group while × represent lack of compatibility of blood group)



Figure 6.6

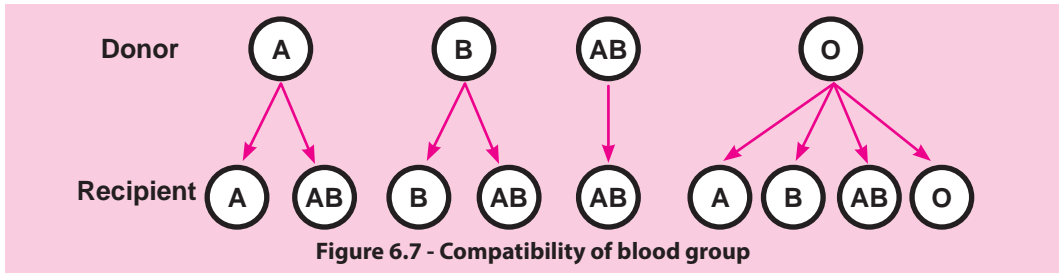
Table 6.1- Compatibility of blood group

D o n o r	Recipient				
	Blood type	A	B	AB	O
A	✓	×	✓	×	
B	×	✓	✓	×	
AB	×	×	✓	×	
O	✓	✓	✓	✓	

According to the table, blood group AB can receive blood from all other blood groups. Therefore, blood group AB is called the **universal recipient**.

Blood group O can donate to all the other blood groups. Therefore, blood group O is called the **universal donor**.

Information in the table 6.1 can be illustrated as in figure 6.7.



For a blood transfusion, not only the blood group, but also the Rhesus factor (Rh factor) must be compatible.

Compatibility of Rhesus factor

If the Rhesus factor is present in one's blood it is considered as Rh⁺ and if Rhesus factor is absent it is considered as Rh⁻. The recipients who are Rh⁺ can receive both Rh⁺ and Rh⁻ blood. However, the Rh⁻ recipients can receive Rh⁻ blood only. The table 6.2 shows the compatibility of blood with Rhesus factor.

(√ represent positive compatibility of blood with Rhesus factor while × represent negative compatibility of blood with Rhesus factor)

Table 6.2 - Compatibility of Rhesus factor

Donor	Recipient	
	Rh ⁺	Rh ⁻
Rh ⁺	√	×
Rh ⁻	√	√

The figure 6.8 represents the same facts in table 6.2.

Hence both the blood group and the Rhesus factor have to be matched to donate blood. Both the blood group and Rhesus factor is considered when expressing the blood group of an individual.

e.g. A⁺, A⁻, B⁺, B⁻, AB⁺, AB⁻, O⁺, O⁻

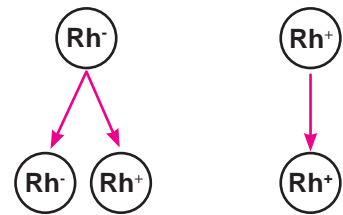


Figure 6.8 - Compatibility of Rhesus factor

The National Blood Transfer Service (NBTS) has a list of other qualifications a donor must fulfill. A donor has to complete the Blood Donor Declaration correctly and hand it over to the NBTS before donating blood. Blood donor declaration and donation record is given in the extra knowledge frame.



For extra knowledge

National Blood Transfusion Service - Sri Lanka Blood Donor Declaration & Donation Record

Donor ref & Barcode

Please read the information leaflets given to you, before filling this declaration form in order to ensure your health and the quality and safety of your valuable donation.

If you cannot fill this form on your own, please get the assistance from a staff member.

Donor's Name	:	_____	Sex	M	F
National ID card No	:	_____	Age	_____	
Address (Home)	:	_____			
Address (Office)	:	_____			
Contact Numbers	:	Home: _____	Office: _____		
(Mobile)	:	_____	Email: _____		
Date	:	_____	Signature: _____		
			Blood Group (if known)	_____	

Please mark 'X' in relevant tick boxes clearly.

1. A) Have you donated blood previously? Yes No
- B) If yes, How many times : _____
- C) Date of last donation : _____
- D) Did you experience any ailment, difficulty or discomfort during previous donations? Yes No
- E) If yes, what was the difficulty? _____
- F) Have you ever been medically advised not to donate blood? Yes No
- G) Have you read and understood the "Blood donors Information Leaflets" given to you? Yes No
2. A) Are you feeling well, today? Yes No
- B) Have you ever had or taken treatment for any of the following disease conditions?
If Yes, please mark X in relevant boxes and discuss with the medical officer during interview
- | | | | | | |
|-------------------|--------------------------|-------------------------|--------------------------|------------------|--------------------------|
| • Heart Disease | <input type="checkbox"/> | • Diabetes | <input type="checkbox"/> | • Fits | <input type="checkbox"/> |
| • Strokes | <input type="checkbox"/> | • Asthma / Lung disease | <input type="checkbox"/> | • Liver diseases | <input type="checkbox"/> |
| • Kidney diseases | <input type="checkbox"/> | • Blood diseases | <input type="checkbox"/> | • Cancer | <input type="checkbox"/> |
- C) Are you taking any medication/ treatment, presently? Yes No
- D) Have you undergone any surgery? Yes No
- E) After donating blood, do you have to engage in heavy work, driving passenger or heavy vehicles or work at heights today? Yes No
- F) (For females) Are you pregnant or breast feeding at present? Have you had a child birth or abortion during last 12 months? Yes No
3. During past 12 months,
- A) Have you received any vaccinations? Yes No
- B) Have you had tattooing, ear / body piercing or acupuncture treatment? Yes No
- C) Have you been imprisoned for any reason? Yes No
- D) Have you or your partner travelled abroad? Yes No
- E) Have you or your partner received blood or blood products? Yes No
4. A) Have you ever had Jaundice in the past? Yes No
- B) During last 2 years: Have you had Tuberculosis or Typhoid or taken treatment for them? Yes No
- C) During last 3 months: Have you had malaria or taken treatment for malaria? Yes No
- D) During last one month: Have you had chicken pox, measles, mumps, rubella, Dengu fever or any other long standing (more than one week) fever? Yes No
- E) During last 1 week: Have you had a dental extraction or have you taken Aspirin, antibiotics or any other medicine? Yes No
5. A) Do you know that people of following categories should not give blood? Yes No
- > If you were found to be positive for HIV, Hepatitis B, C or Syphilis infections at any time.
 - > If you have ever injected any drug (esp., Narcotics) not prescribed by a qualified medical practitioner
 - > If you have ever worked as a sex worker
 - > If you have ever engaged in male to male sexual activity
 - > If you have had sex with a sex worker or unknown partner during last 1 year
 - > If you have had multiple sex partners during last 1 year
 - > If you suspect that you or your partner may have got HIV or any other sexually transmitted infection
- B) Do you or your sexual partner belong to one of the above categories? Yes No
- C) Are you having persistent fever, diarrhoea, multiple swollen glands or unintentional weight loss? Yes No

Please remember

Unsafe blood can destroy lives

Donor's Declaration

- I have read and understood the information regarding blood donation and answered all the above questions honestly and correctly and donating my blood voluntarily today, for the benefit of patients.
- I also agree to follow the instructions given to me by the NBTS, during and after blood donation and accept the responsibility of any consequences of not following those instructions.
- Further, I give my consent to test my donated blood for HIV, Syphilis, Hepatitis B & C, Malaria and any other required test in any manner deemed appropriate by the NBTS Sri Lanka.
- Further I give my consent to be informed about the results of the above tests, as and when required by the NBTS and also to follow any instructions given to me in this regard by the NBTS.

I AM WILLING TO BE A REGULAR BLOOD DONOR TO SAVE MANY MORE HUMAN LIVES THROUGH DONATING BLOOD

Once in 4 months
 Once in 6 months
 Once a year

Donor's Name: _____ Signature: _____ Date: _____

Donation Record (for office use only)

Donation no. & barcode

MEDICAL ASSESSMENT Medical officer's name/ sig: _____

Donor's Name: _____

Weight

History Feeling unwell/ Inadequate sleep (<5hrs)? / Fasting (> 4hrs)?
Any current illnesses, Allergies or medications? High risk behaviours? (Q5 review)

Examination W look/ Pallor/ icterus? / Alcohol smell? / Infected wounds? / Venepuncture site lesions?
CVS status Pulse: _____ BP: _____ Remarks: _____

Counselling Importance of blood safety/ Option for CUE/ Possibility of calling back.

Outcome Donor to be accepted if Hb > 12g/dl Temporary deferral Permanent deferral

Remarks / Reasons for Deferral: _____

REGISTRATION Registering Officer's Signature: _____

- Check Donor Name and ID card No for correctness, before registration.

Hb level > 12g/dl <12g/dl Blood bag type: G T D S

BLOOD COLLECTION Phlebotomist's Name / Sign: _____

- Check the correctness of the Donor's name and Donation no.

Start time: _____ End time: _____ Volume (ml): _____

Signature of the collecting person: _____

Blood agglutination

Clumping of the transfused blood particles in the body of the recipient is called **agglutination**.

This happens when the blood groups of donor and recipient are incompatible.

Blood clotting/ coagulation is an important process that prevents excessive bleeding when there is an injury or internal bleeding. This coagulation mechanism differs from the coagulation mechanism of agglutination.

When there is an injury or bleeding, the platelets at the damaged blood vessels breakdown and the resulting chemical process forms a blood clot to stop bleeding.

Maintaining a proper functioning of the blood circulatory system is vital for a healthy life of a person.

Some favourable habits to maintain healthy blood circulation system

- Maintain mentally less stressful lifestyle
- Engage in physical exercises daily
- Maintain the correct Body Mass Index (BMI) value according to height and weight, with a healthy diet.
- Reducing salt consumption
- Control conditions like high blood pressure and diabetes
- Adding more vegetables and fruits to meals
- Reduce consumption of fatty foods
- Refrain from smoking and liquor
- Have more concern if there is a family history of heart attacks, high blood pressure, and diabetes



Assignment 6.3

- Collect newspaper cuttings about the good health habits that should be followed to maintain a healthy blood circulatory system.
- Share that knowledge with your classmates.



Summary

- The human heart has four chambers.
- The upper chambers are the right atrium and left atrium and the lower chambers are the right ventricle and left ventricle.
- Aorta is connected to the left ventricle while pulmonary artery is connected to the right ventricle.
- Left and right pulmonary veins are connected to the left atrium while superior vena cava and inferior vena cava are connected to the right atrium.
- Semi lunar valves are at the beginning of main arteries.
- Bicuspid valve is between the left ventricle and left atrium.
- Tricuspid valve is between the right atrium and right ventricle.
- The blood vessels that take the blood away from the heart are arteries and the vessels that take the blood towards the heart are veins.
- An artery ends up with a capillary and a vein starts with a capillary.
- The main functions of blood are transport and protection.

- Depending on the protein component in blood cells there are four blood groups A, B, AB and O.
- Compatibility of the blood group and the Rhesus factor between the donor and the recipient is important for blood transfusion.
- AB is the universal recipient and O is the universal donor.
- Clumping of the transfused blood particles in the body of the recipient is known as blood agglutination.
- The mechanism of blood coagulation during an injury differs from the mechanism of blood coagulation in the process of agglutination.
- There is a list of qualifications a donor must fulfill.
- It is vital to maintain a healthy blood circulatory system.

Exercise

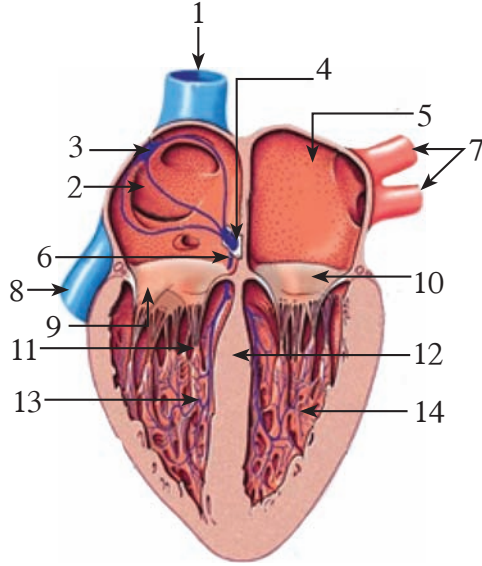
01) Select the correct or most suitable answer.

- Aorta starts from
 1. Left ventricle
 2. Right ventricle
 3. Left atrium
 4. Right atrium
- What are the blood types that can be transfused for a person with the blood group B
 1. A and B
 2. A and O
 3. O and B
 4. A and AB
- The universal donor and the universal recipient is
 1. A and O
 2. A and B
 3. O and AB
 4. AB and O
- Following are some ideas given by a student about blood transfusion.
 - a. Compatibility of blood group is compulsory
 - b. Rh⁻ blood can be transfused for a person with Rh⁺
 - c. Only Rh⁻ blood can be transfused for a person with Rh⁻.
 The correct statements are,
 1. a and b Only
 2. b and c Only
 3. a and c Only
 4. a, b and c
- During an internal bleeding the blood cells that help for blood coagulation are,
 1. Red blood cells
 2. White blood cells
 3. Platelets
 4. Plasma

6. Followings are some ideas given by a student about the functions of blood.
- Carries oxygen to the body cells
 - Kill pathogenic micro-organisms
 - Agglutination occurs when transferring blood
- a and b only
 - b and c only
 - a and c only
 - a, b and c

02) Give short answers.

1. Use only the numbers in the figure when you answer the given questions related to the human heart.



- What are the two veins that open to the right atrium?
 - Write the numbers of bicuspid valve and tricuspid valve.
 - Write down the names of the four chambers and the relevant numbers
2. Write five good habits that help in maintaining a healthy circulatory system.

Technical Terms

Blood circulatory system	-	ரூபிர சஃசர஢ ஃடீ஢கிஃ	-	குருதிஃ சுற்றோட்டத் தொகுதி
Blood groups	-	ரூபிர ஂ஢	-	குருதி வகைகள்
Blood transfusion	-	ரூபிர ஃரஃலீஃஃ	-	குருதிக் குறுக்குப் ஃாய்ச்சல்
Universal donor	-	ஃரஃஃ ஃுஃஃஃ	-	சர்வ வழங்கி
Universal recipient	-	ஃரஃஃ ஃுதிஃஃஃஃ	-	சர்வ வஃங்கி
Rhesus factor	-	ரீஃஃ ஃு஢கிஃ	-	ரீஸஸ் கஃரணி
Agglutination	-	ஃலீஃஃஃ	-	ஃருங்கொட்டல்