Subject code:	Bio1	Fundamentals of Biology
Learning Guide Code:	3.0	Transport and Circulation of Materials
Lesson Code:	3.3	Human Cardiovascular System
Time Limit:		30 minutes (1 session)

MATERIALS

To complete this module, you need the following:

1. pen and paper
2. phone/tablet/laptop
3. stable internet connection

TARGET (1 min)

At the end of this module, you should be able to identify the parts of the human cardiovascular system and give the function of each.

HOOK (2 mins)

The heart is one of the important organs in the body which pumps the blood in our systems. It is also that one organ that we can probably associate to a number of things including life and love. **But how did this blood pumping organ become a symbol or shape that resemble such things?**

One of the probable reasons would concern the plant silphium, a plant used as a perfume, seasoning and medicine in the ancient times. Some sources say that the shape of the heart may have been brought forth because artists and scientists from the Middle Ages tried to make representations from ancient medical scripts.

Figure 1. *Silphium terebinthinaceum*. By Mason Brock (Masebrock) - Own work, Public Domain, https://commons.wikimedia.org/w/index.php?curid=65931510

IGNITE (16 mins)

The Heart

The **heart** is a hollow, cone-shaped pump which is muscular in nature. It lies in the thoracic cavity and just beneath it is the diaphragm. Its size varies with the size of the individual. The heart is bordered laterally by our lungs and is located within the mediastinum, the partition along the thoracic cavity.

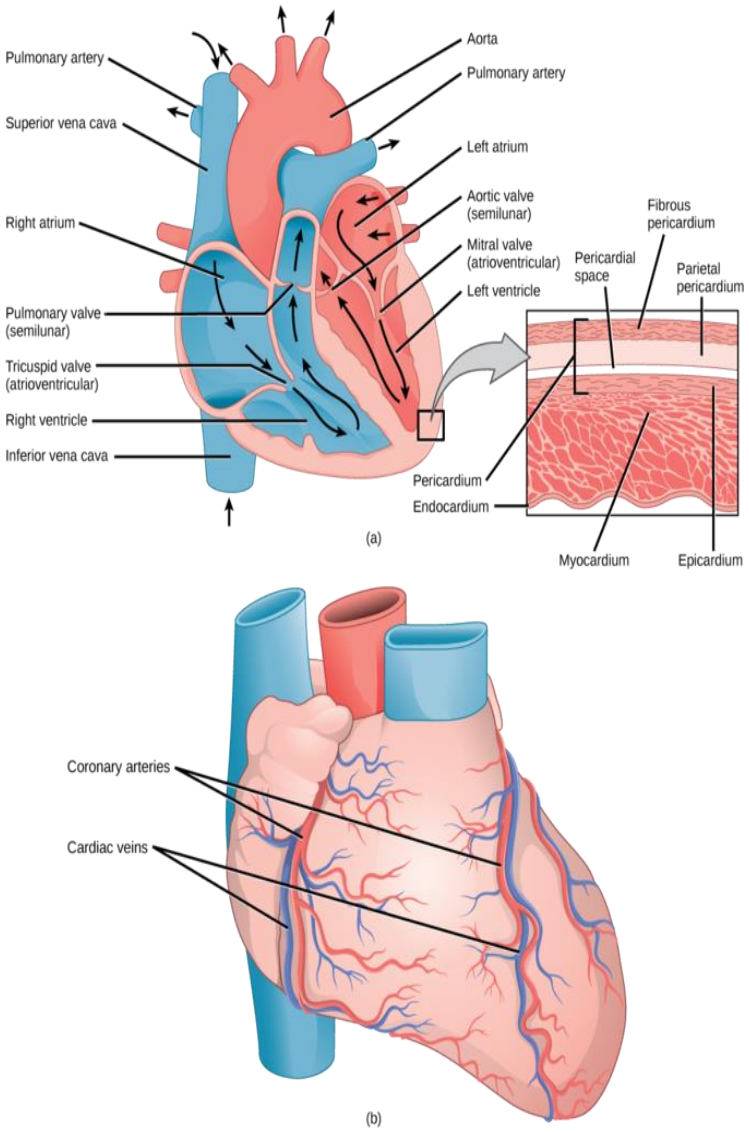

Figure 1. Major Structures of the Human Heart (https://bio.libretexts.org/Bookshelves/Introductory_and_General_Biology/Book%3A_General_Biology_(Boundless)/40%3A_The_Circulatory_System/40.3%3A_Mammalian_Heart_and_Blood_Vessels/40.3A%3A_Structures_of_the_Heart licensed by CC-BY-NC-SA 3.0)

Illustrated in Figure 1, we can see that there is a covering that encloses the heart called the **pericardium**. The wall of the heart is composed of three layers – the outer **epicardium**, the middle **myocardium** and the inner **endocardium**. Internally, the human heart has four distinct chambers – two on the right and two on the left.

The upper chambers are called the **atria**. These upper chambers have thin walls and act as receiving chambers for blood returning to the heart. The lower chambers on the other hand are the **ventricles** which receive blood from the atria. The contraction of these ventricles pumps out blood out of the heart.

The **right atrium** and **ventricle** are separated from their **left counterparts** by a wall-like structure, the **septum**. This is the reason why blood from the right side of the heart will never mix with the blood from the left side. The blood would pass through a **valve** as it leaves a chamber. These valves function to prevent backflow of blood.

__ RESEARCH!
What are the valves found in the heart? What are their functions? **This is not graded.**

The Blood Vessels

The blood is carried throughout the body via a complex network of **blood vessels**. These include the **arteries, arterioles, capillaries, venules** and **veins**. The layers of these vessels as shown in Figure 2, reflect their functions in our circulatory system. The inner layer, **tunica intima** is a smooth lining of endothelial cells and has contact with the blood. The middle layer is the **tunica media** which comprises the majority of the arterial walls. The outermost layer on the other hand is the **tunica externa** which attaches the vessels to the surrounding tissues. In contrast to arteries and veins, capillaries only have one layer of tunic instead of three.

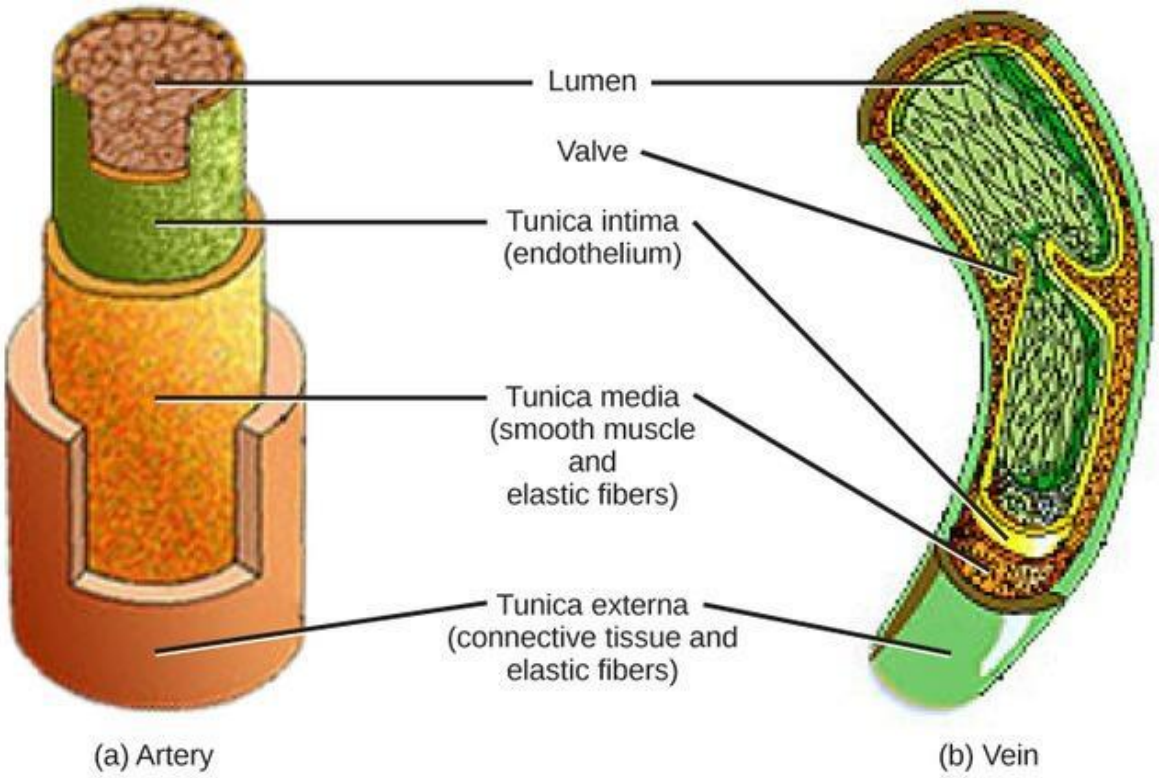

Figure 2. Structure and Layers of Blood Arteries and Veins (https://bio.libretexts.org/Bookshelves/Introductory_and_General_Biology/Book%3A_General_Biology_(Boundless)/40%3A_The_Circulatory_System/40.3%3A_Mammalian_Heart_and_Blood_Vessels/40.3B%3A_Arteries%2C_Veins%2C_and_Capillaries licensed by CC-BY-NC-SA 3.0)

Arteries and Arterioles

Arteries are strong and elastic blood vessels that function for carrying blood away from the heart. The **aorta** is the largest artery in the body. It can be subdivided into three sections namely, the ascending aorta, the aortic arch, and the descending aorta (composed of the thoracic aorta and the abdominal aorta).

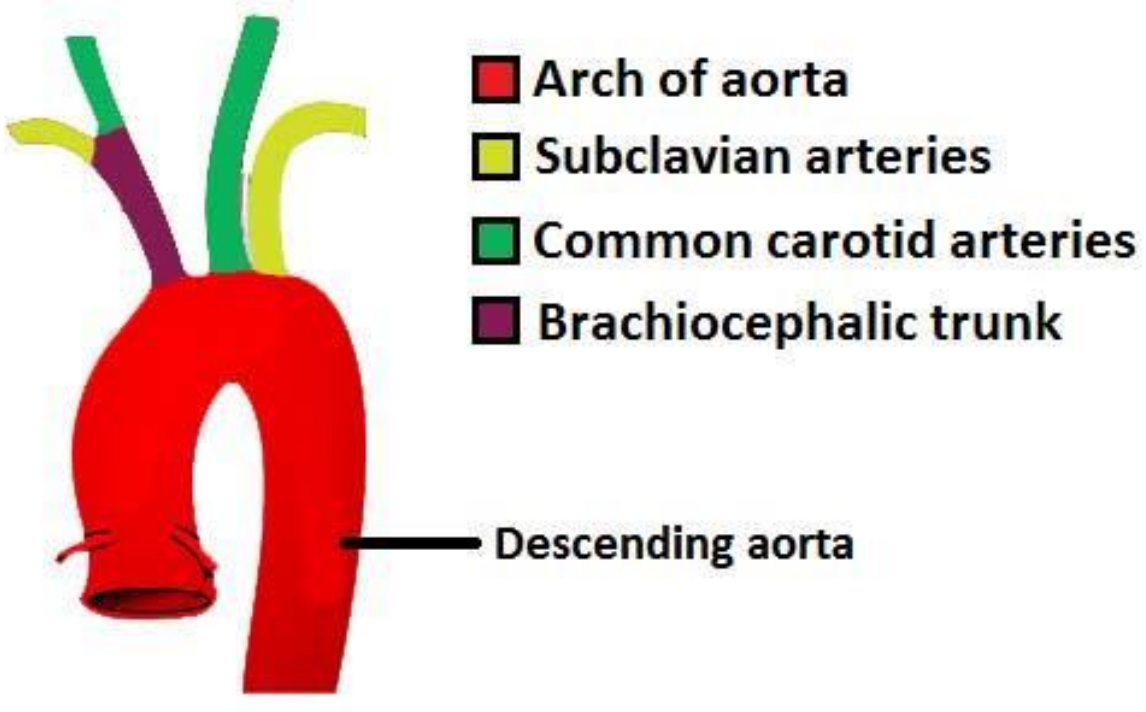

Figure 3. Parts of the Aorta.(https://teachmeanatomy.info/abdomen/vasculature/ arteries/aorta/. Licensed under CC BY-SA 3.0 by Wikimedia Commons)

The **ascending aorta** rises from the left ventricle to become the aortic arch. It is around 2 inches long. The right and the left aortic sinuses are dilations in the ascending aorta which give rise to the coronary arteries that supply blood to the myocardium, the muscular tissue of the heart.

The **aortic arch** is an extension of the ascending aorta and has three major branches arising from the arch. The three branches would supply blood to different areas. Complete the table below with the right information about the branches of the aortic arch. This is a non-graded activity.

Table 1. Branches of the Aortic Arch.

Branch	Site where it supplies the oxygenated blood
Brachiocephalic trunk	
Left common carotid artery	
Left subclavian artery	

The **descending aorta** continues from the aortic arch down to the diaphragm. The abdominal aorta continues from the thoracic aorta and it branches out to the blood vessels that supply the lower extremities with oxygenated blood.

Apart from the aorta, one of the major arteries in the body is the **pulmonary artery**. It carries with it deoxygenated blood from the heart to the lungs. The blood in here passes through the capillaries in the alveoli and becomes oxygenated.

Capillaries

In terms of the diameter, **capillaries** are considered to be the smallest of all the blood vessels. Their thin walls form a semipermeable tissue by which exchange of materials occur between the blood and the fluid surrounding the body cells. There are thin slits in the capillary walls where endothelial cells are observed to be overlapping. These slits vary in size depending on the tissues where they are found.

The density of capillaries also reflects the tissues' **metabolism rates**. Muscles and nerve tissues which consume high amounts of oxygen and nutrients are supplied with more capillaries while those with slower rates of metabolism like that of our cartilages are supplied with lesser capillaries. To some extent some parts of our body lack capillaries entirely like that of our eye's cornea.

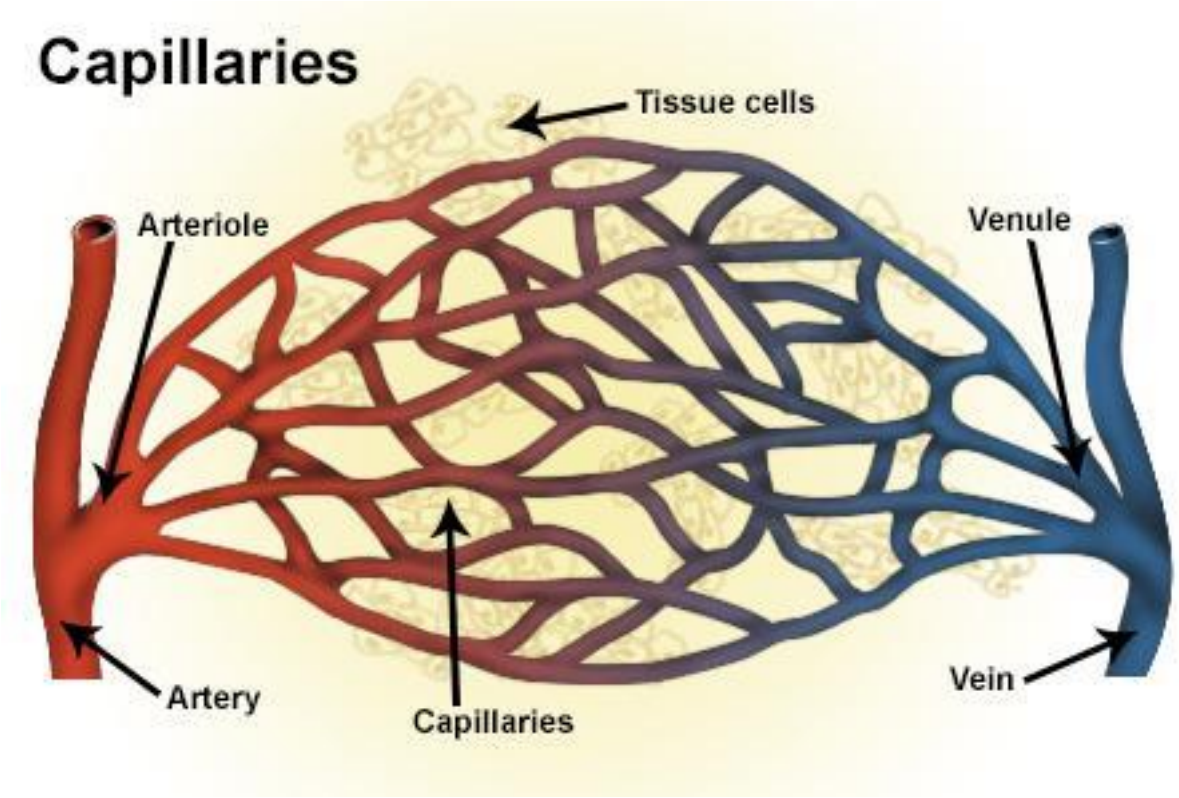

Figure 4. Illustration of blood vessels including artery, arteriole, capillaries, vein and venule (https://commons.wikimedia.org/wiki/Category:Capillaries#/media/File:Capillaries.jpg Licensed by Creative Commons CC0 License)

Venules and Veins

Veins and venules are responsible for bringing back blood back to the heart. Venules extend from the capillaries and merge forming the veins. The walls of the veins are somewhat similar to that of the arteries but the middle layer of a vein's wall is poorly developed compared to an artery's wall. The walls of veins are thinner compared to that of the arteries, yet their lumens have greater diameter.

Most veins, especially those in the upper and lower limbs have **valves**. These are flap-like structures projecting inward from their inner linings. The two flaps comprising a valve close when there is backflow of blood. These valves also help in returning the blood back to the heart since they are open as long as the blood flows toward the heart, but close when there is backflow.

The pulmonary veins are responsible for carrying oxygenated blood from the lungs to the heart, while the larger circuit that is made up of the systemic veins carries deoxygenated blood from the body back to the heart.

The Blood

Our **blood** is the bodily fluid responsible for delivering essential substances like nutrients and oxygen in the body. It is composed of the plasma, the liquid portion containing water, electrolytes and other important molecules, the red blood cells, the white blood cells and the platelets.

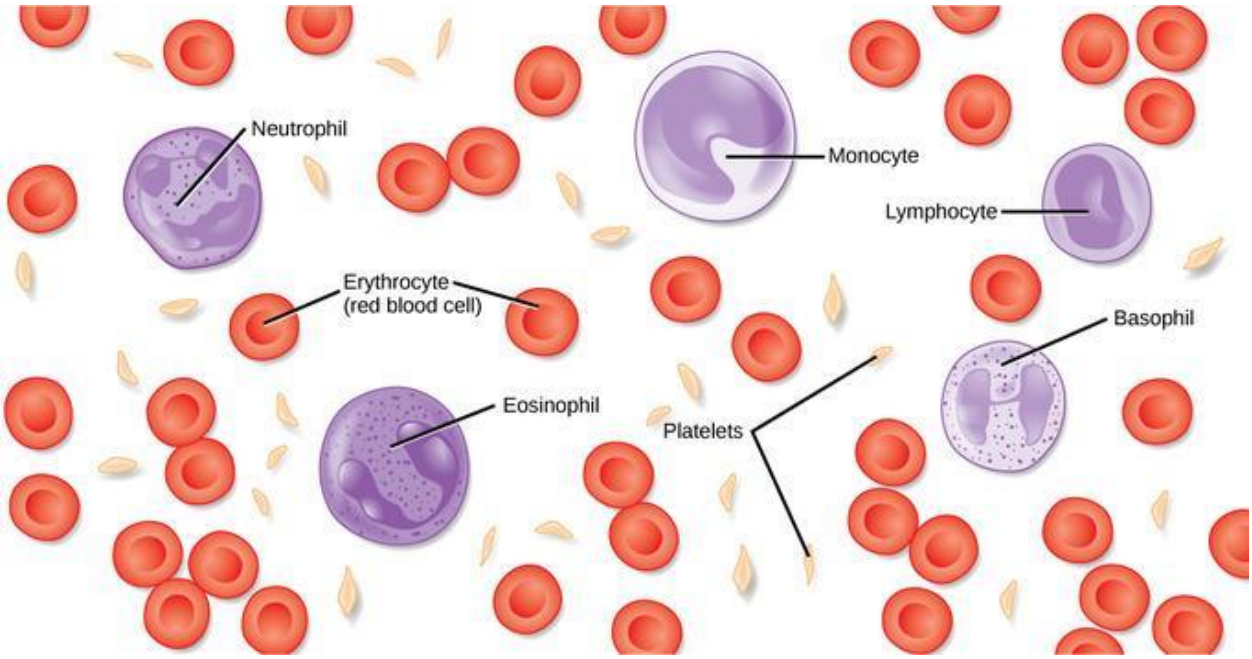

Figure 5. The components of the blood. (https://bio.libretexts.org/Bookshelves/Introductory_and_General_Biology/Book%3A_General_Biology_(Boundless)/40%3A_The_Circulatory_System/40.2%3A_Components_of_the_Blood/40.2A%3A_The_Role_of_Blood_in_the_Body licensed by CC-BY-NC-SA 3.0)

__ RESEARCH!
What are the other functions of the blood apart from transporting important materials? **This is not graded.**

Red Blood Cells

Red blood cells (RBC) or **erythrocytes** are distinct for their shapes. They are biconcave disk cells having a diameter of around 8 micrometers. Their cell membranes are strong and flexible allowing them to deform but resist rupture even if they squeeze through thin capillaries. The cytoplasm of an RBC contains hemoglobin and consists of about 1/3 of the cell's mass. During maturity, RBCs lose their nucleus making it possible to have more spaces available for oxygen transport.

__ RESEARCH!
Why is the red blood cell biconcave in shape? What advantage does this shape give? **This is not graded.**

White Blood Cells

White blood cells (WBC) or **leukocytes** are the components of the blood playing an important role in immune response. In contrast to the RBCs, WBCs have a nucleus and are complete with all other organelles. WBCs may be classified as granular or agranular depending on the presence or absence of observable cytoplasmic granules as illustrated in Figure 6.

Granular leukocytes display distinct granules that can be observed using a light microscope. It may either be a neutrophil, eosinophil and basophil. **Agranular leukocytes** on the other hand have cytoplasmic granules but are not visible under the microscope due to their size and poor staining quality. Agranular leukocytes include the lymphocytes and monocytes.

Figure 6. The different kinds of White Blood cells and their observable features. (https://bio.libretexts.org/Bookshelves/Introductory_and_General_Biology/Book%3A_General_Biology_(Boundless)/40%3A_The_Circulatory_System/40.2%3A_Components_of_the_Blood/40.2C%3A_White_Blood_Cells licensed by CC-BY-NC-SA 3.0)

Platelets

Platelets are tiny cell fragments that are formed from the disintegration of **megakaryocytes** as shown in Figure 7. A disintegration of one megakaryocyte could form around 3000 platelets sized at 2-4 micrometers in diameter.

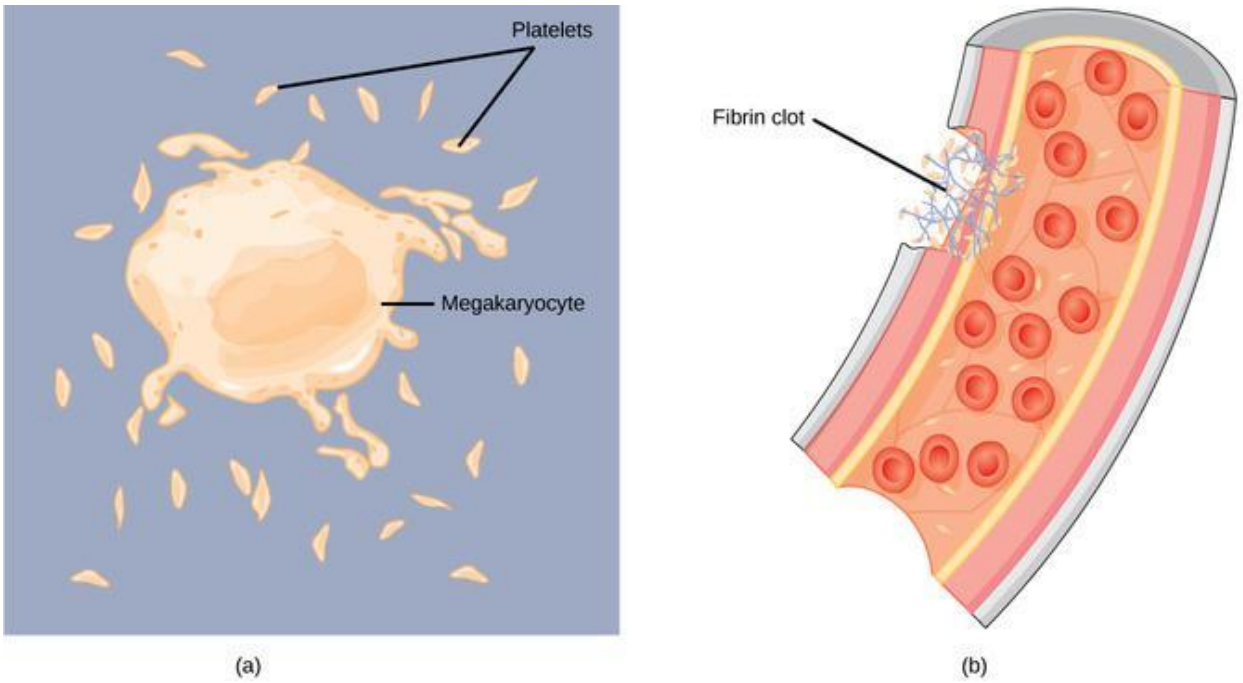

Figure 7. The (a) formation of platelets and (b) their blood-clotting action in a wound. (https://bio.libretexts.org/Bookshelves/Introductory_and_General_Biology/Book%3A_General_Biology_(Boundless)/40%3A_The_Circulatory_System/40.2%3A_Components_of_the_Blood/40.2D%3A_Platelets_and_Coagulation_Factors licensed by CC-BY-NC-SA 3.0)

Platelets are merely fragments of a cell yet it has structures important to stop bleeding. They contain proteins on their surfaces allowing them to clot to break in the blood vessel wall.

Adhesion is the process by which these cell fragments form a clot. Whenever there is an injury, platelets begin to connect to each other, forming a plug in the process of **aggregation** as shown in Figure 8.

This triggers the platelets to release their contents to activate other platelets. The contents also interact with **coagulation factors**, including **thrombin** (from the inactive form called prothrombin) that are important in the conversion of fibrinogen to **fibrin**, a protein that strengthens the blood clot.

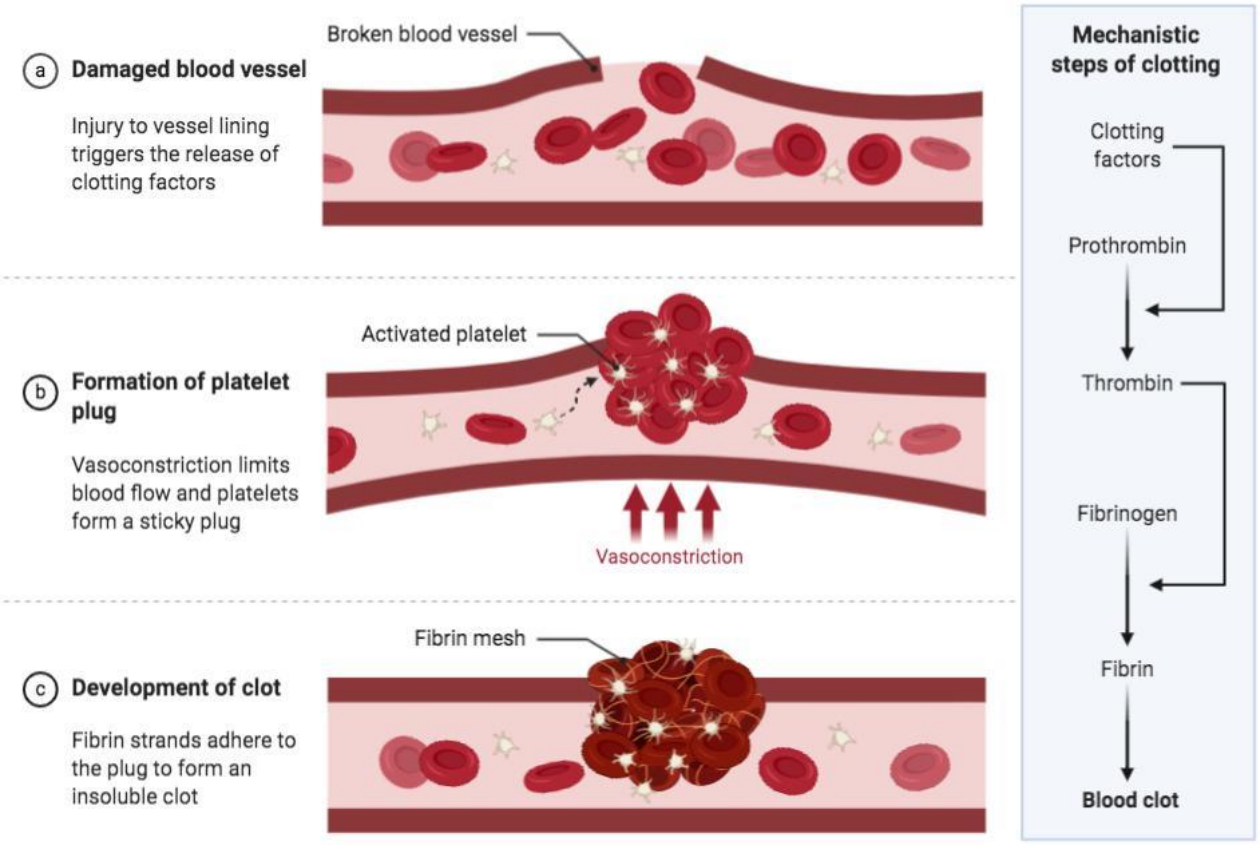

Figure 8. Formation of blood clot in a broken blood vessel. Image from Fogelson, A.L. et al.. (2012) Blood Clot Formation under Flow: The Importance of Factor XI Depends Strongly on Platelet Count.. Biophys J.

NAVIGATE (10 mins)

The circulatory system is composed of different formed elements that are essential in different processes. In the table below, write the needed information to complete your review of the blood's component. In the first column, draw the appearance of the blood component listed by looking into photos online or from textbooks.

This is a graded assessment worth 13 points (1pt per component). Submit your answers in PDF format following the file name format: **SURNAME_SECTION_BIO1_Q2_LG3.3**

Table 2. Characteristics and Functions of Different Parts of the Circulatory System.

Name and appearance	Relative number or concentration in the blood	Characteristics	Functions
The Heart			
Arteries			
Veins			
Capillaries			
Blood			

Red Blood Cells			
White Blood Cells			
• Neutrophils			
• Eosinophils			
• Basophils			
• Lymphocytes			
• Monocytes			
Platelets			

KNOT (1 min)

The **circulatory system** which is composed of the heart, the blood vessels and the blood, is responsible for providing oxygen and nutrients to and removes waste materials from cells in our body.

The **heart** is a muscular organ around 14 centimeters long and 9 centimeters wide located within the mediastinum. Its outside covering is called the pericardium. The heart also has three layers—the epicardium, myocardium and endocardium. It is also divided into two atria and two ventricles. A system of blood vessels is connected to the heart. These intricate networks carry blood to the different parts of the body back to heart. **Arteries** are adapted to conduct blood away from the heart, withstanding high amounts of pressure. The arteries tend to decrease in size as they move farther from the heart, forming arterioles which are continuous with **capillaries**. In these capillaries, exchange of materials happens. Their thin walls create a semipermeable wall that allows exchange of materials between the blood and the body fluids. These capillaries are continuous with the venules and **veins**, which are the conduits of blood back to the heart. The blood is another important part of the system which is composed of different elements with different functions.

References/Sources:

Fogelson, A.L. et al. (2012) Blood Clot Formation under Flow: The Importance of Factor XI Depends Strongly on Platelet Count. Biophys J.from: https://app.biorender.com/community/gallery/s-5eb47d6201291500b42316e2-the-formation-process-of-a-blood-clot-in-a-broken-blood-vess

Overview of the Circulatory System (2019) Retrieved from: https://bio.libretexts.org/Bookshelves/Introductory_and_General_Biology/Book%3A_General_Biology_(OpenStax)/7%3A_Animal_Structure_and_Function/40%3A_The_Circulatory_System/40.1%3A_Overview_of_the_Circulatory_System.

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