Anatomy and Physiology: The Cardiovascular System

CHAPTER 1

The cardiovascular system, also known as the circulatory system, is a complex network of organs and vessels responsible for circulating blood throughout the body. It consists of:

- Blood: the fluid in which materials are transported to and from tissues.
- Blood vessels: the system by which the blood moves to and through tissues and back to the heart.
- Heart: the pump driving blood throughout the body.

Blood provides the fluid environment for the cells of the body with blood vessels transporting the blood. Blood vessels are the network carrying the blood. The heart performs its work as a pump, maintaining blood circulation. The cardiovascular system is essential for maintaining overall health and homeostasis, ensuring all cells receive the necessary oxygen and nutrients whilst removing waste products.

Circulation is key to maintaining organs and tissues. This chapter discusses the anatomy and physiology of the cardiovascular system, the system maintaining blood volume and perfusion of tissues and organs. Understanding how circulation is fundamental to maintaining organs and tissues can help enhance patient care and safety across all spheres of practice.

BLOOD

Through the blood (and lymph) substances are transported around the body; it is the main transportation system of the body, playing a critical role in maintaining homeostasis and supporting the functioning of various body systems. Blood performs three general functions:

1. Transport: transportation of substances around the body, delivering oxygen to every cell.
2. Regulation: blood regulates fluid and electrolyte balance, acid–base balance (pH) and temperature.
3. Protection: clotting factors are present in the blood (thrombocytes), helping protect the body from haemorrhage; blood also contains leucocytes; they help fight infection.

COMPOSITION OF BLOOD

A red sticky fluid, blood is classified as a connective tissue despite its fluid nature. Connective tissues connect, support and bind together various structures and organs in the body. Blood has several different components and can vary slightly from person to person; it can change in response to factors such as hydration, diet and overall health.

Blood consists of formed elements, for example, red blood cells (erythrocytes), white blood cells (leucocytes) and platelets (thrombocytes) (see Table 1.1).

Table 1.1 The three types of blood cells

Blood cell	Description	Role
Erythrocytes	Make up 90% of the formed elements of blood. Disc shaped (bi-concave). Young red blood cells contain a nucleus (nucleated), while this is absent in mature red blood cells, thereby increasing the oxygen-carrying capacity of the cell. Red in colour due to the presence of the protein haemoglobin (Hb). Formed in the red bone marrow. Life span of approximately 120 days. Old and worn-out erythrocytes are destroyed in the liver and spleen.	Transportation of gases (take oxygen to cells and carry carbon dioxide away from cells).
Leucocytes	These are the largest of all blood cells. They lack Hb and, as such, are white in colour. Two categories: Granulocytes: Accounting for 75% of white blood cells, further divided into neutrophils, eosinophils and basophils. Agranulocytes: Divided into lymphocytes, 20% of all white blood cells and monocytes account for 5% of white blood cells. Leucocytes often only survive for a few hours but may live for months or years.	Provides the body with protection against infection and disease through the process of phagocytosis (engulfing and ingesting microbes, dead cells and tissues).
Thrombocytes	Also known as platelets. Granular, disc shaped with no nucleus. Small fragments of cells. The smallest cellular elements of blood. Formed in bone marrow. Life span of a thrombocyte is short – five to nine days.	Responsible for initiating the blood clotting process leading to the development of blood clots. These blood cells prevent blood loss from a blood vessel by: Gathering where a blood vessel is injured. Forming a plug at the injured site and releasing fibrinogen (a chemical) and converting this to fibrin (the net that holds the clot together).

The fluid portion of blood, plasma, contains different types of proteins and other soluble molecules. When a blood sample is separated, the formed elements account for 45% of blood and plasma makes up 55% of the total blood volume. Normally, more than 99% of the formed elements are cells named for their red colour (red blood cells). White blood cells and platelets comprise less than 1% of the formed elements (Figure 1.1). Between the plasma and erythrocytes is the buffy coat, consisting of white blood cells and platelets. See Figure 1.2 for the three formed elements of blood.

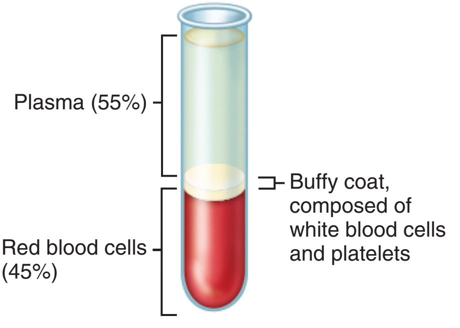

FIGURE 1.1 Appearance of centrifuged blood

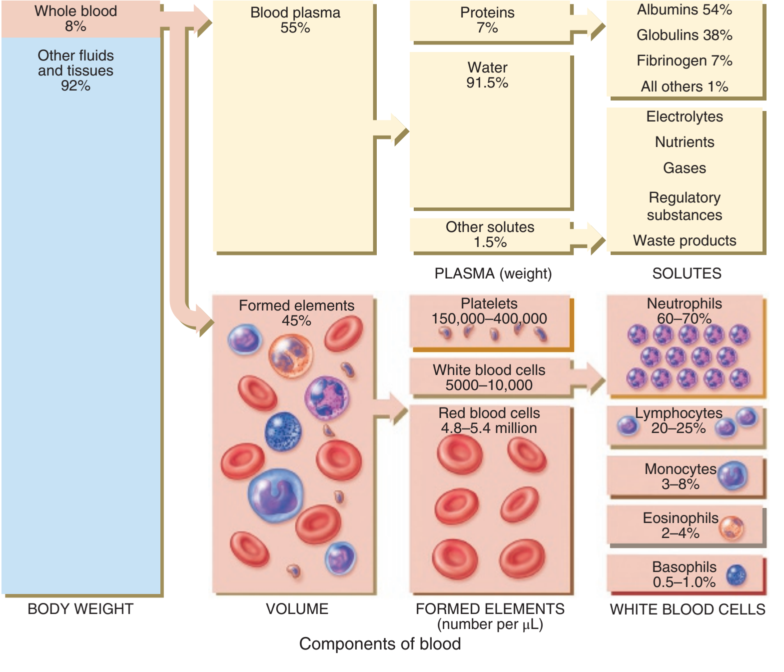

FIGURE 1.2 Three formed elements of blood

The volume of blood is constant unless a person has physiological problems, for example, haemorrhage.

PROPERTIES OF BLOOD

The average adult has a blood volume of approximately 5 L, accounting for 7–9% of the body's weight. Men have 5–6 L and women 4–5 L of blood. Blood is thicker, denser and flows slower than water due to the red blood cells and plasma proteins. Plasma proteins, including albumin, fibrinogen, prothrombin and gamma globulins, make up around 8% of blood plasma in the body (Tortora and Derrickson 2017). These proteins help maintain water balance, affecting osmotic pressure, increasing blood viscosity and helping to maintain blood pressure. The plasma proteins, apart from the gamma globulins, are synthesised in the liver.

Blood has a high viscosity, resisting blood flow. Red blood cells and proteins contribute to the viscosity of blood, which ranges from 3.5 to 5.5 compared with 1.000 for water. Viscosity relates to stickiness of blood; normal viscosity of blood is low, allowing it to flow smoothly. However, the more red blood cells and plasma proteins in blood, the higher the viscosity and the slower the flow of blood. Normal blood varies in viscosity as it flows through the blood vessels; the viscosity decreases as it reaches the capillaries.

Plasma Plasma is a straw-coloured aqueous solution containing plasma proteins, i.e. albumin, globulins and fibrinogen. It also contains inorganic ions regulating cell function, blood pH and osmotic pressure; these include sodium, potassium, chloride, phosphate, magnesium and calcium. Small amounts of nutrients, waste products, drugs, hormones and gases are also found in plasma. Figure 1.3 shows the composition of blood plasma along with the different types of formed elements in the blood.

Plasma is around 91.5% water with 8.5% solutes and most are proteins. Some of the proteins in blood plasma are found elsewhere in the body; those confined to blood are known as plasma proteins. Specific blood cells develop into cells producing gamma globulins, an important type of globulin; these are called antibodies or immunoglobulins, produced during specific immune responses. Other solutes in plasma include electrolytes, nutrients, regulatory substances, such as enzymes and hormones, gases as well as waste products such as urea, uric acid, creatinine, ammonia and bilirubin.

FORMATION OF BLOOD CELLS

Red bone marrow is the primary centre for haemopoiesis. Bone marrow is the soft fatty substance found in bone cavities. Within the bone marrow, all blood cells originate from a single type of unspecialised cell, a stem cell. When a stem cell divides, it first becomes an immature red blood cell, white blood cell or platelet-producing cell. The immature cell divides, matures further and eventually becomes a mature red blood cell, white cell or platelet. Haemopoiesis describes the process by which the formed elements of blood develop (Figure 1.4).

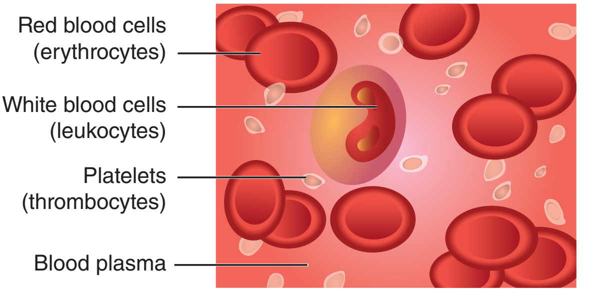

FIGURE 1.3 Components of blood

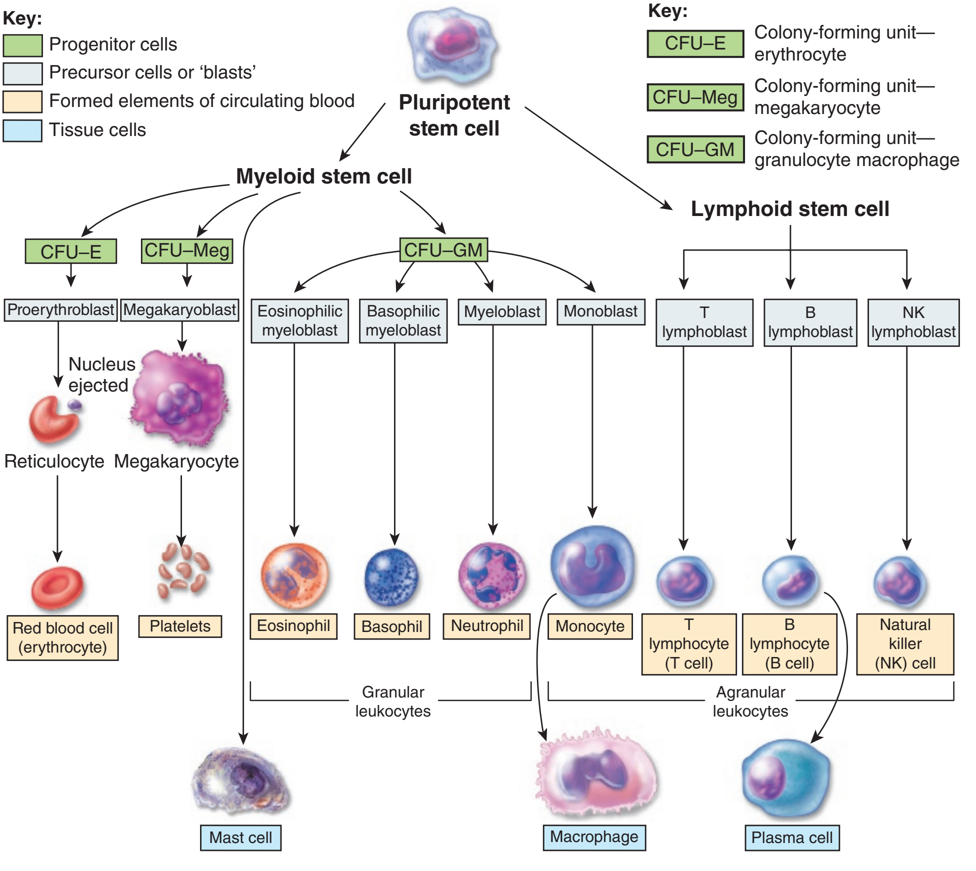

FIGURE 1.4 Haemopoiesis

BLOOD GROUPS

Red blood cells define which blood group an individual belongs to. On the surface of red cells are markers called antigens. Apart from identical twins, each person has different antigens

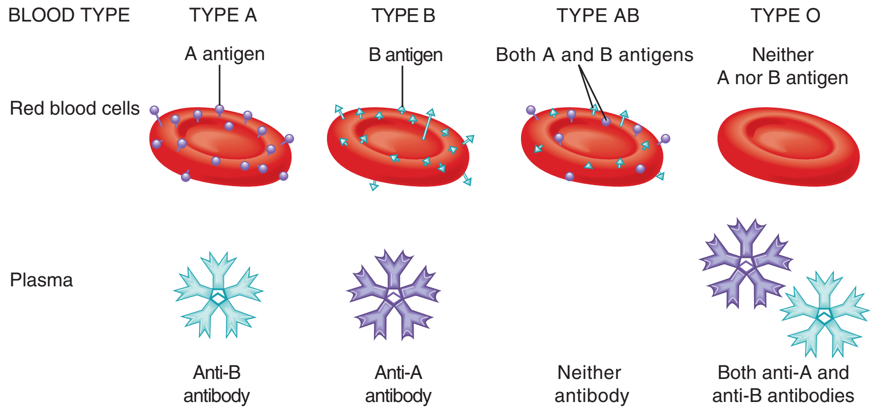

FIGURE 1.5 ABO blood groups

and these antigens are the key to identifying blood types and must be matched in transfusions to avoid serious complications. The structure for defining blood groups is known as the ABO system. If an individual has blood group A, then they have A antigens covering their red cells. Group B has B antigens on their red blood cells, while group O has neither antigens and group AB has both antigens (see Figure 1.5).

The ABO system also covers antibodies in the plasma, the body's natural defence against foreign antigens, for example, blood group A has anti-B in their plasma, B has anti-A and so on. However, group AB has no antibodies and group O has both. If these antibodies find the wrong red blood cells, they attack them and destroy them. Transfusing the wrong blood to a patient can be fatal.

BLOOD VESSELS

Blood vessels are part of the circulatory system transporting blood throughout the body. There are three major types of blood vessels (see Figure 1.6):

1. Arteries carry blood away from the heart.
2. Capillaries enable the actual exchange of water, nutrients and chemicals between blood and tissues.
3. Veins carry blood from capillaries back towards the heart.

The different types of blood vessels are specialised, playing a specific role in circulating the blood around the body.

All arteries, except pulmonary and umbilical arteries, carry oxygenated blood; most veins carry deoxygenated blood from tissues back to the heart; exceptions are the pulmonary and umbilical veins, which carry oxygenated blood. The capillaries form the microcirculatory system; at this point, nutrients, gases, water and electrolytes are exchanged between blood and tissue fluid. Capillaries are tiny, extremely thin-walled vessels acting as a bridge between arteries and veins. The thin walls of capillaries allow oxygen and nutrients to pass from the blood into the tissue fluid and allow waste products to pass from tissue fluid into blood.

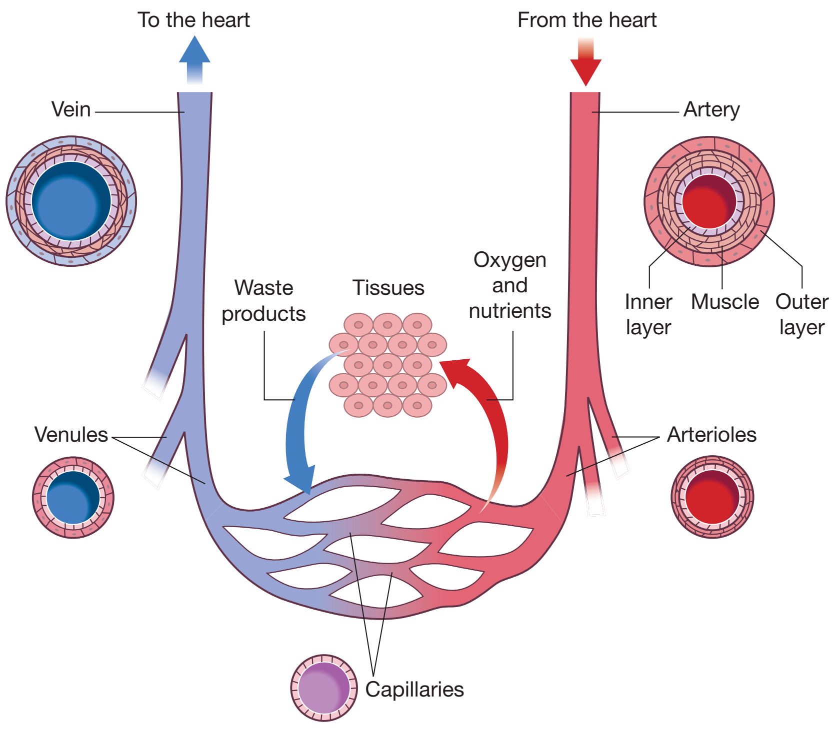

FIGURE 1.6 Blood vessels

STRUCTURE AND FUNCTION OF ARTERIES AND VEINS

In most blood vessels, the walls consist of three layers:

1. Tunica interna (a thin layer of endothelial cells. The epithelial lining is only one cell thick. Therefore, this layer is always very thin.)
2. Tunica media (consists of smooth muscle and elastic fibres).
3. Tunica externa (an outer layer, consisting of fibroblasts, nerves and collagenous tissue).

See Figure 1.7, layers of blood vessels.

ARTERIES

Arteries receive blood under high pressure from the ventricles. They must stretch each time the heart beats, without collapsing under the increased pressure. The walls of arteries have three layers.

1. Outer layer
2. Thick middle layer
3. Inner layer

The outer layer consists of white fibrous connective tissue, merging into the outside with the loose connective tissue. This helps anchor the arteries as the heart pumps the blood

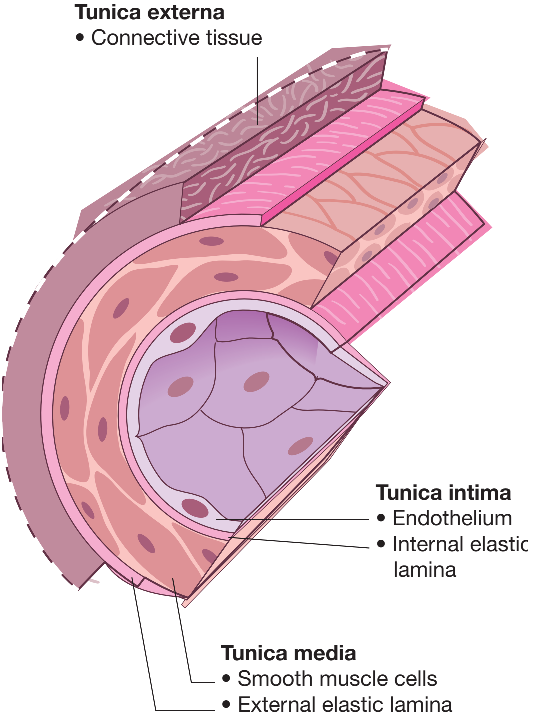

FIGURE 1.7 Layers of blood vessels

through arteries at great pressure (Blanchflower and Peate 2021). The thick middle layer consists of elastic connective tissue and involuntary muscle tissue. This layer is supplied with two sets of nerves: one that stimulates muscles to relax, so the artery is permitted to widen and the other stimulates circular muscles to contract, causing the artery to become narrower. The inner layer of endothelium is made up of flat epithelial cells packed closely together, continuous with the endocardium of the heart. The flat cells make the inside of the arteries smooth to limit friction between blood flowing within the artery and the lining of the vessel.

VEINS

The veins are the major vessels of the venous system. As veins carry blood back to the heart, the pressure exerted by the heartbeat on them is much less than in the arteries. The middle muscular wall of a vein is much thinner than an artery and generally the diameter is larger. Veins also differ from arteries in that they have semilunar valves helping prevent blood from flowing backwards. Figure 1.8 shows a comparison of a vein, artery and capillary.

The vein's valves are necessary to keep blood flowing towards the heart; they are also required to allow blood to flow against the force of gravity; for example, blood returning to the heart from the foot must be able to flow up the leg. Generally, the force of gravity would discourage that from happening. The vein's valves, however, provide 'footholds' for blood as it flows its way up. The valves are like gates, only allowing traffic to move in one direction. They also act with muscle contraction, squeezing the veins and propelling blood towards the heart.

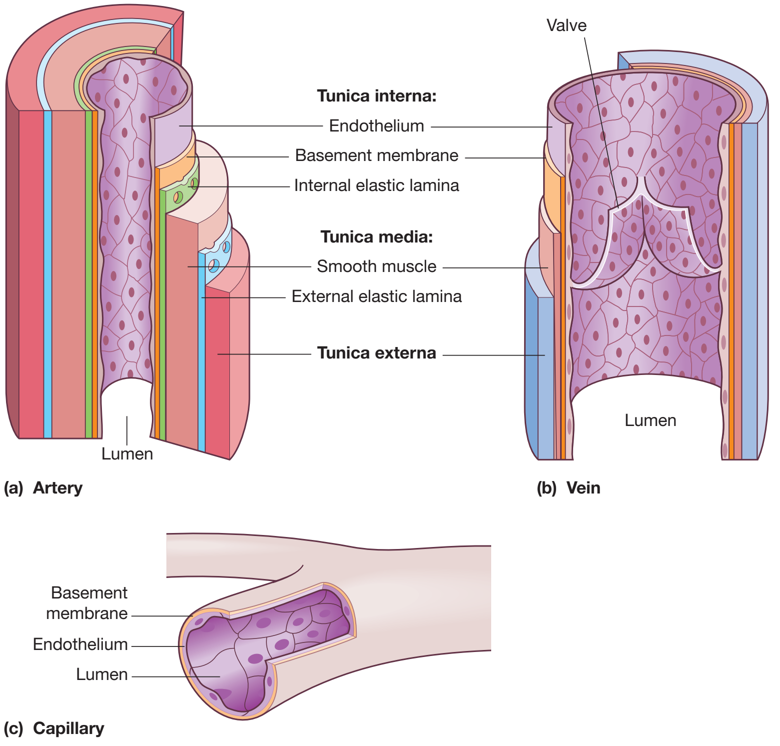

FIGURE 1.8 Comparison of a vein, artery and capillary

Veins receive blood from capillaries after the exchange of oxygen and carbon dioxide has occurred. Veins transport carbon dioxide–rich blood back to the lungs and heart. It is important that carbon dioxide–rich blood keeps moving in the right direction and is not allowed to flow backward; this is accomplished by the semilunar valves present in the veins.

CAPILLARIES

Capillaries are tiny blood vessels of approximately 5–20 μm in diameter. There are networks of capillaries (Figure 1.9) in most organs and tissues. Capillary walls are composed of a single layer of cells, the endothelium. This layer is so thin that molecules such as oxygen, water and lipids can pass through it by diffusion and enter tissues. Waste products such as carbon dioxide and urea can diffuse back into the blood to be carried away for removal from the body. Capillaries are so small, red blood cells must change their shape to pass through them in single file.

The flow of blood in the capillaries is controlled by structures known as precapillary sphincters. These are located between arterioles and capillaries and contain muscle fibres, allowing them to contract. When the sphincters are open, blood flows freely to the capillary beds of body tissue. When the sphincters are closed, blood cannot flow through the capillary beds. Fluid exchange between the capillaries and the body tissues takes place in the capillary bed.

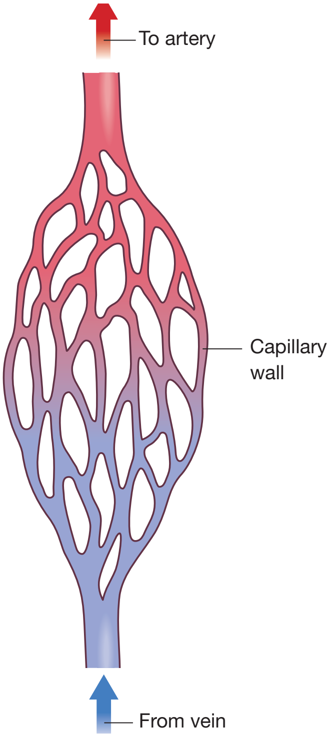

FIGURE 1.9 Capillary network

HEART

This is the hollow muscular pump that forces the movement of blood around the body.

It weighs approximately 250–390 g in men and 200–275 g in women and is about 12 cm long and 9 cm wide. It is in the thoracic cavity (chest) in the mediastinum (between the lungs), behind and to the left of the sternum (breastbone) (Figure 1.10). The heart rests on the diaphragm in the thoracic cavity.

WALLS OF THE HEART

Pericardium A membrane, the pericardium surrounds the heart. This is referred to as a single sac surrounding the heart but is in fact made up of two sacs (fibrous pericardium and serous pericardium) closely connected to each other. These sacs have different structures (Figure 1.11).

Fibrous Pericardium It is a tough, inelastic layer made up of dense, irregular, connective tissue. Its purpose is to prevent overstretching of the heart. It also provides protection to the heart and anchors it in place.

Serous Pericardium It is a thinner, more delicate structure forming a double layer around the heart. The outer layer is fused to the fibrous pericardium. The visceral pericardium (otherwise known as the epicardium) adheres tightly to the surface of the heart.

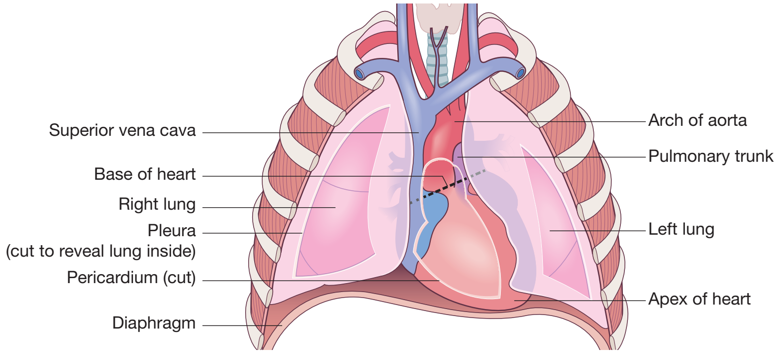

FIGURE 1.10 The location of the heart

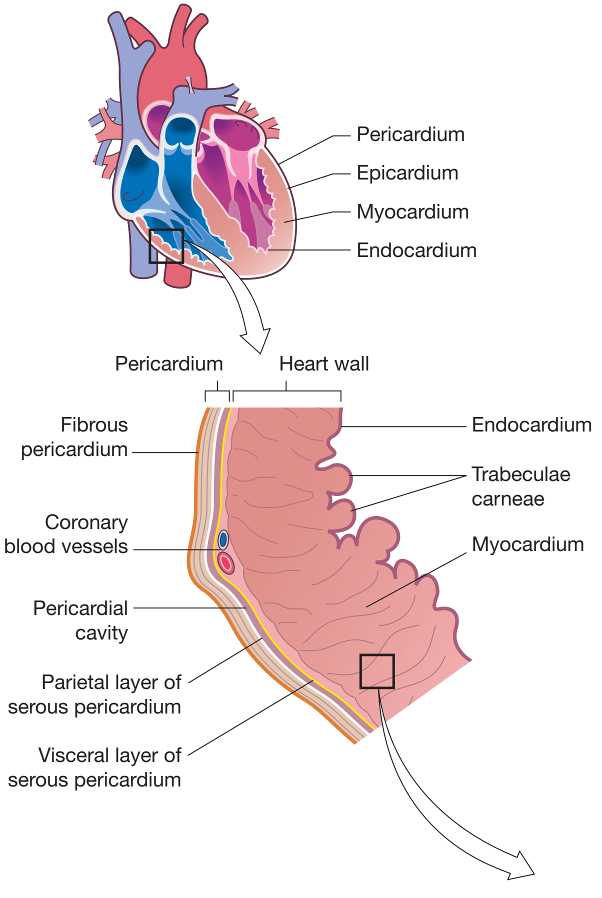

FIGURE 1.11 The walls of the heart

Myocardium The myocardium makes up most of the bulk of the heart. It is a muscle only found within the heart, specialised in structure and function. The work of the myocardium can be divided into two parts: much of the myocardium is specialised to undertake mechanical work (contraction); the remainder is specialised to undertake the task of initiating and conducting electrical impulses. The cardiac muscle cells (myocytes) are held together in interlacing bundles of fibres arranged in a spiral or in circular bundles (Figure 1.12).

Myocardial thickness varies between all chambers of the heart. Ventricles have thicker walls than atria; however, the left ventricle has the thickest myocardial wall. This is because the left ventricle must pump blood great distances to parts of the body at a higher pressure and the resistance to blood flow is greater.

Endocardium The innermost layer is made up of endothelium overlying a thin layer of connective tissue. The endothelium is continuous with the endothelial lining of the large vessels of the heart. It also provides a lining allowing blood to flow through the chambers smoothly.

CHAMBERS OF THE HEART

The heart has four chambers: two atria (left and right; singular is atrium) and two ventricles (left and right). On the anterior surface of each of the atria is a wrinkled pouch-like structure called an auricle; the main function is to increase the volume of blood in the atrium. Between the ventricles is a dividing wall, the intraventricular septum (Figure 1.13). With the septum between the atria and the septum between the ventricles, there is no mixing of blood between the two sides.

VALVES OF THE HEART

Between the atria and ventricles are two valves (atrioventricular [AV] valves).

- Tricuspid valve – made up of three cusps (leaflets) lying between the right atrium and the right ventricle.
- Bicuspid (mitral) valve – made up of two cusps lying between the left atrium and the left ventricle.

The AV valves prevent the backward flow of blood from the ventricles into the atria.

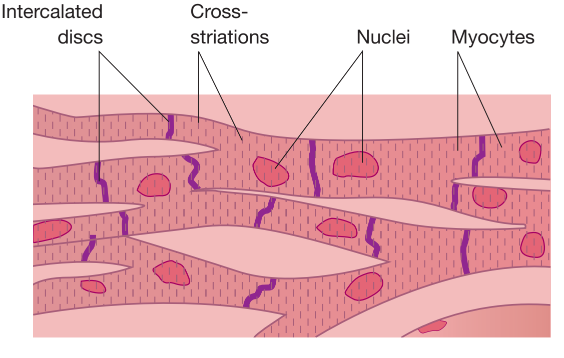

FIGURE 1.12 Cells of the myocardium

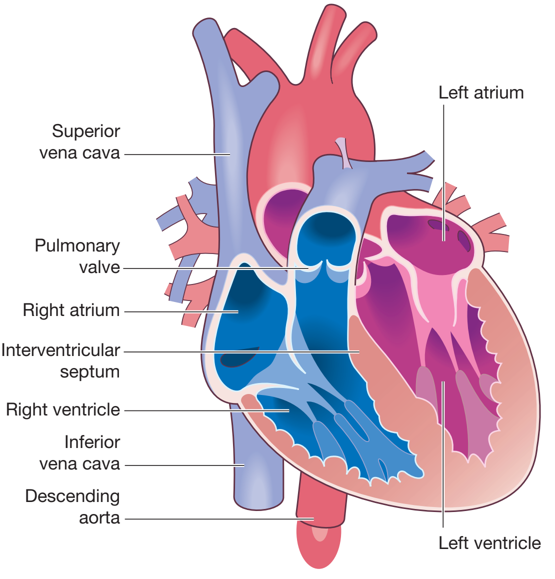

FIGURE 1.13 The chambers of the heart

BLOOD VESSELS OF THE HEART

The aorta is the largest blood vessel of the heart and the largest blood vessel in the body. The aorta carries and distributes oxygen-rich blood to all arteries. The coronary arteries are the first blood vessels branching off from the ascending aorta, supplying richly oxygenated and nutrient-filled blood to the myocardium. There are two main coronary arteries: the right and left coronary artery. Other arteries diverge from these two main arteries, and they extend to the lower portion of the heart.

The pulmonary arteries are unique in that, unlike most arteries transporting oxygenated blood to other parts of the body, pulmonary arteries transport deoxygenated blood to the lungs. After picking up oxygen in the lungs, the oxygen-rich blood is returned to the heart via the pulmonary veins. There are four pulmonary veins extending from the left atrium to the lungs:

1. Right superior vein
2. Right inferior vein
3. Left superior vein
4. Left inferior pulmonary vein

The venae cavae (superior and inferior) (singular vena cava) are the two largest veins in the body, and they carry deoxygenated blood from the various regions of the body to the right atrium. As deoxygenated blood is returned to the heart and continues to flow through the cardiac cycle, it is transported to the lungs where it will become oxygenated. The blood then travels back to the heart and from here it is pumped out to the rest of the body via the aorta. The oxygen-depleted blood is returned to the heart again via the venae cavae.

BLOOD FLOW THROUGH THE HEART

The circulatory system has three distinct parts:

1. Pulmonary circulation (lungs)
2. Coronary circulation (heart)
3. Systemic circulation (systemic)

The heart's parts must work together in a coordinated manner for effective function.

Pulmonary Circulation This is a system of blood vessels forming a closed circuit between the heart and lungs. Blood enters the heart through two large veins, the inferior and superior vena cava, emptying oxygen-poor blood from the body into the right atrium. Blood flows from the right atrium into the right ventricle through the open tricuspid valve. When the ventricles are full, the tricuspid valve shuts. This prevents the blood from flowing backwards into the atria while the ventricles contract (squeeze).

Once the blood travels through the pulmonary valve, it enters the lungs; this is the pulmonary circulation. From the pulmonary valve, blood travels to the pulmonary artery to tiny capillary vessels in the lungs. Here, oxygen travels from the tiny air sacs in the lungs, through the walls of the capillaries, into the blood. At the same time, carbon dioxide, a waste product of metabolism, passes from blood into the air sacs. Carbon dioxide leaves the body as we exhale. Once the blood is oxygenated, it then travels back to the left atrium through the pulmonary veins (Figure 1.14).

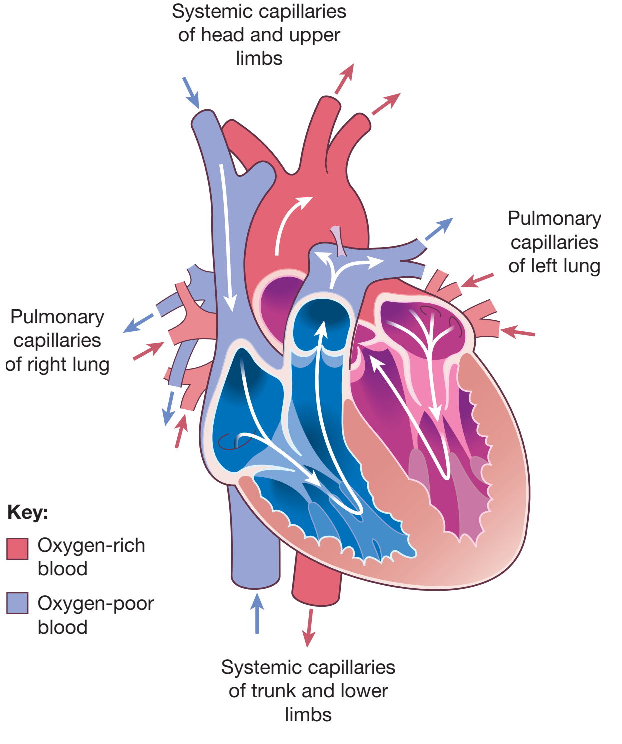

FIGURE 1.14 Blood flow through the heart

Systemic Circulation This is the circuit of vessels supplying oxygenated blood to and returning deoxygenated blood from the tissues. The pulmonary vein empties oxygen-rich blood from the lungs into the left atrium.

Blood leaves the heart through the aortic valve, into the aorta, then to the body (systemic circulation). This pattern is repeated, causing blood to flow continuously to the heart, lungs and body.

The powerful contraction of the left ventricle forces blood into the aorta, which then branches into many smaller arteries running throughout the body. The inside layer of an artery is very smooth, allowing blood to flow quickly. The outside layer of an artery is very strong, enabling blood to flow forcefully. The oxygen-rich blood enters the capillaries where oxygen and nutrients are released. Waste products are collected and the waste-rich blood flows into veins to circulate back to the heart where pulmonary circulation allows the exchange of gases in the lungs to occur.

Coronary Circulation The heart receives about 5% of the body's blood supply. It is essential that the heart receives a plentiful supply of blood to ensure the constant supply of oxygen and nutrients and the efficient removal of waste products required by the myocardium so it performs at an optimum level.

Nutrients from blood cannot diffuse quickly from the heart chambers to supply the cells of the heart. Only the inner part of the endocardium (about 2 mm thick) is supplied with blood directly from the inside of the heart chambers. The rest of the heart's blood supply is supplied by coronary arteries. The coronary arteries come directly off the aorta, just after the aortic valve. They continuously divide into smaller branches and form a web of blood vessels to supply the heart muscle (Figure 1.15).

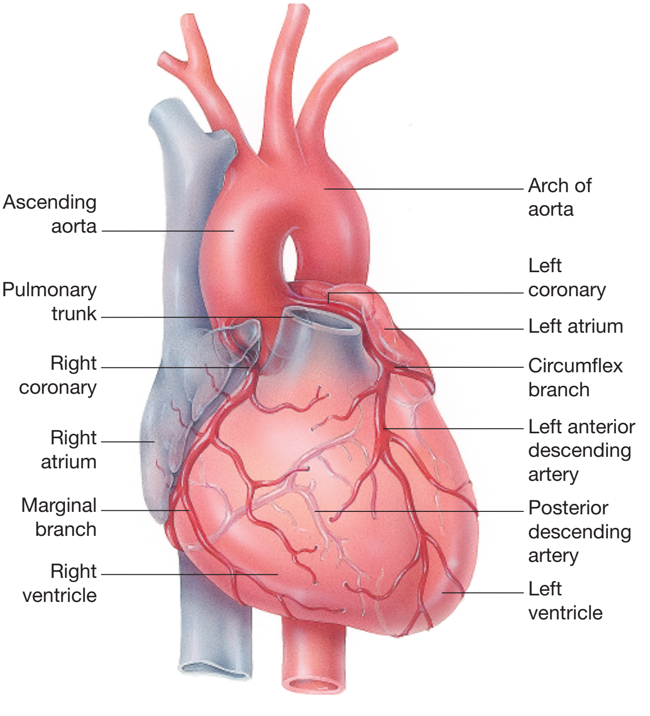

FIGURE 1.15 Blood vessels of the heart

CORONARY ARTERIES

The entire body must be supplied with nutrients and oxygen via the circulatory system; the heart is no exception. The coronary circulation refers to vessels supplying and draining the heart.

Coronary arteries supply blood to the myocardium. As with all other tissues, the heart muscle requires oxygen-rich blood for it to function, and oxygen-depleted blood has to be carried away.

The coronary arteries branch from the ascending aorta, encircling the heart like a crown. As the coronary arteries are compressed during each heart beat, blood does not flow through the coronary arteries at this time. Thus, blood flow to the myocardium occurs during the relaxation phase of the cardiac cycle, the opposite to every other part of the body.

The left coronary artery divides into the anterior interventricular branch, supplying oxygenated blood to both ventricles and the circumflex branch, which distributes oxygenated blood to the left ventricle and left atrium. The right coronary artery divides into the right posterior descending and acute marginal arteries and supplies oxygenated blood to the right atrium and both ventricles, sinoatrial (SA) node (cluster of cells in the right atrial wall regulating the heart's rhythmic rate) and AV node.

CORONARY VEINS

The coronary veins return deoxygenated blood (containing metabolic waste products) from the myocardium to the right atrium. This blood then flows back to the lungs for reoxygenation and removal of carbon dioxide.

Coronary veins contain valves preventing back flow. The coronary sinus is a collection of veins joined together forming a large vessel that collects blood from the myocardium (Figure 1.16). It delivers deoxygenated blood to the right atrium.

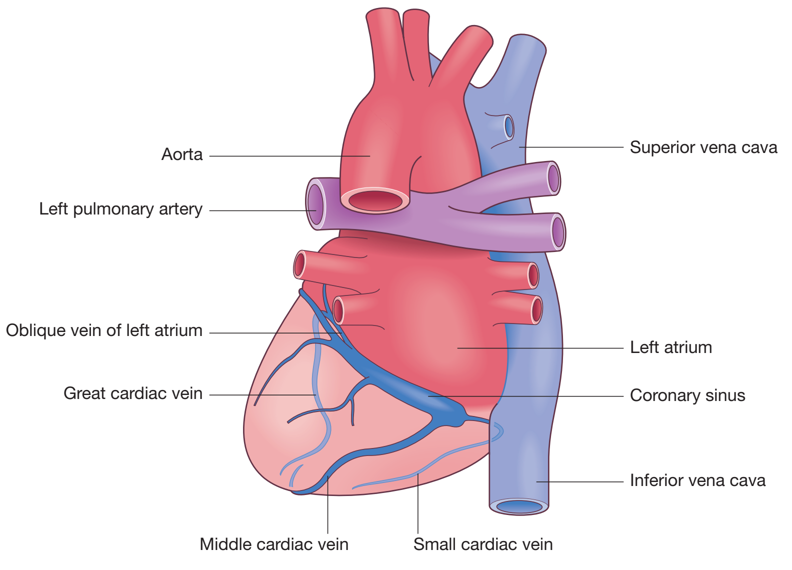

FIGURE 1.16 Coronary veins

The coronary sinus opens into the right atrium, at the coronary sinus orifice, between the inferior vena cava and the right AV orifice. It returns blood from the substance of the heart and is protected by a semi-circular fold of the lining membrane of the auricle.

THE CONDUCTING SYSTEM

The cardiac conduction system is composed of a collection of nodes and specialised conduction cells that initiate and coordinate contraction of the heart muscle. Cardiac conduction is the rate at which the heart conducts electrical impulses. These impulses usually result in the heart contracting and then relaxing. The constant cycle of heart muscle contraction followed by relaxation causes blood to be pumped throughout the body. The conduction pathway is made up of five elements:

1. SA node
2. AV node
3. Bundle of His
4. Left and right bundle branches
5. Purkinje fibres

SA Node The SA node is the natural pacemaker of the heart, located in the right atrium (see Figure 1.17). The SA node is a spindle-shaped structure composed of a fibrous tissue matrix with closely packed specialist cells (Peate 2022). The SA node releases electrical stimuli at a regular rate. The rate at which they are released is determined by the needs of the body. Each stimulus passes through the myocardial cells of the atria, creating a wave of contraction which spreads at speed through both atria.

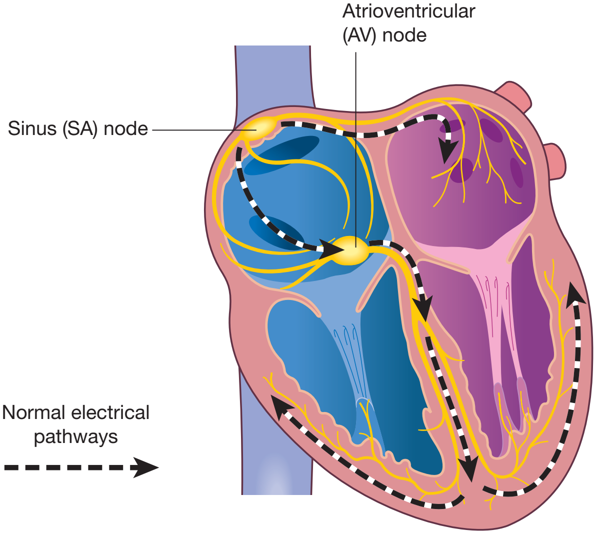

FIGURE 1.17 The conducting system of the heart

The heart is composed of around half a billion cells. The majority of the cells make up the ventricular walls. The rapidity of atrial contraction is such that around 100 million myocardial cells contract in less than one-third of a second, so fast that the contraction of the atria appears instantaneous.

AV Node The AV node is situated on the right side of the partition dividing the atria (see Figure 1.17). When impulses from the SA node reach the AV node, they are delayed for about a tenth of a second. This delay permits the atria to contract and empty their contents first. The AV node regulates the signals to the ventricles, preventing rapid conduction (atrial fibrillation), as well as making sure that the atria are empty and closed before stimulating the ventricles.

Bundle of His Also known as the AV bundle, it is a collection of heart muscle cells specialised for electrical conduction transmitting electrical impulses from the AV node to the point of the apex of the fascicular branches (Nangle 2021). This bundle is the only site where action potentials can be conducted from the atria to the ventricles.

Left and Right Bundle Branches These are the parts of the network of specialised conducting fibres transmitting electrical impulses within the ventricles. Bundle branches are a continuation of the AV bundle, extending from the upper part of the intraventricular septum. The AV bundle divides into a left and a right branch, each going to its respective ventricle by passing down the septum and below the endocardium. Within the ventricles, the bundle branches subdivide, terminating in the Purkinje fibres.

Purkinje Fibres This network of specialised cells is rich with glycogen and has extensive gap junctions; the fibres are located in the inner ventricular walls. They consist of specialised cardiomyocytes that can conduct cardiac action potentials more quickly and efficiently than any other cells in the heart. Purkinje fibres allow the heart's conduction system to create synchronised contractions of its ventricles and are therefore essential for maintaining a consistent heart rhythm.

THE CARDIAC CYCLE

The cardiac cycle is the sequence of events occurring when the heart beats (Figure 1.18). There are two phases of the cardiac cycle. In the diastole phase, the ventricles are relaxed and the heart fills with blood. In the systole phase, the ventricles contract and pump blood to the arteries. One cardiac cycle is completed when the heart fills with blood and the blood is pumped out of the heart.

First Diastole Phase During the diastole phase, the atria and ventricles are relaxed and the AV valves are open. Deoxygenated blood from the superior and inferior venae cavae flows into the right atrium. The open AV valves permit blood to pass through to the ventricles. The SA node contracts, triggering atrial contraction. The right atrium empties its contents into the right ventricle. The tricuspid valve prevents blood from flowing back into the right atrium.

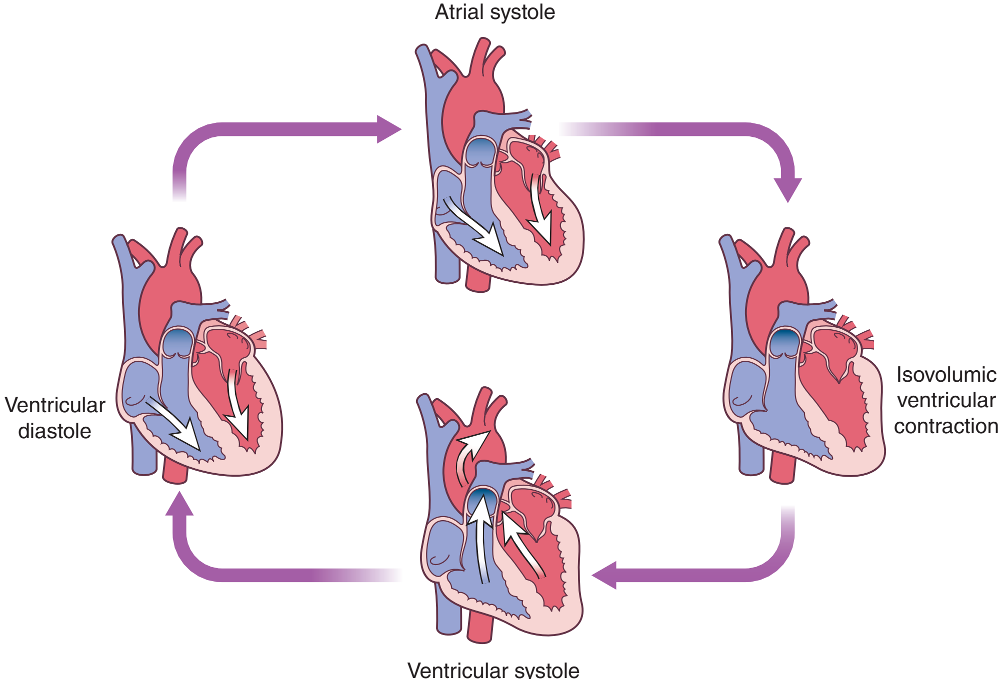

FIGURE 1.18 The cardiac cycle

First Systole Phase During this phase, the right ventricle receives impulses from the Purkinje fibres and it contracts. The AV valves close, and the semilunar valves open. Deoxygenated blood is pumped into the pulmonary artery. The pulmonary valve prevents blood from flowing back into the right ventricle. The pulmonary artery carries blood to the lungs, and gas exchange occurs. Oxygenated blood returns to the left atrium via pulmonary veins.

Second Diastole Phase In the next diastole period, semilunar valves close and AV valves open. Blood from the pulmonary veins fills the left atrium (blood from the venae cavae also fills the right atrium.) The SA node contracts again, triggering atrial contraction. The left atrium empties its contents into the left ventricle. The mitral valve prevents oxygenated blood from flowing back into the left atrium.

Second Systole Phase During the following systole phase, AV valves close and semilunar valves open. The left ventricle receives impulses from the Purkinje fibres and contracts. Oxygenated blood is pumped into the aorta. The aortic valve prevents oxygenated blood from flowing back into the left ventricle. The aorta provides oxygenated blood to all parts of the body. The oxygen-depleted blood is returned to the heart via the venae cavae.

CONCLUSION

The circulatory system is a complex system dealing with the distribution of nutrients, gases, electrolytes, removal of waste products of metabolism and other substances.

This chapter has provided an exploration of the cardiovascular system, seeking to provide readers with a foundation in this sophisticated and vital aspect of human anatomy and physiology.

The cardiovascular system is the lifeline of the body, serving as the transport network for oxygen, nutrients, hormones and waste products. Understanding its structure and function is paramount, as it forms the basis for comprehending a wide range of patient conditions and care interventions. Having insight and understanding of the anatomy and physiology of the cardiovascular system is the cornerstone of your ability to assess patients, interpret diagnostic tests and administer treatments effectively.

This knowledge will be invaluable when assessing heart sounds, detecting irregularities and interpreting electrocardiograms. Haemodynamics and blood pressure are concepts that are critical for comprehending conditions such as hypertension as well as for administering medications and interventions to manage blood pressure effectively. Your understanding will directly impact your practice whether you are monitoring a patient's vital signs, caring for individuals with cardiovascular diseases or assisting in cardiac procedures; this foundational knowledge is indispensable.

Care provision is not just about understanding the science but also about providing compassionate, patient-centred care. Those people with cardiovascular conditions may experience fear, anxiety and vulnerability. Your understanding of the cardiovascular system will enable you to communicate effectively, provide emotional support and deliver holistic care.

In the upcoming chapters, we will further explore cardiac assessments, common cardiovascular disorders, interventions and the art of delivering patient-centred care in the context of cardiovascular health.

GLOSSARY OF TERMS

Aorta: Largest artery in the body, originating from the left ventricle of the heart and carrying oxygenated blood to the systemic circulation.

Arteries: Blood vessels carrying oxygenated blood away from the heart to the body's tissues and organs.

Arterioles: Small branches of arteries that regulate blood flow to the capillaries.

Atria (singular: atrium): Upper chambers of the heart (right atrium and left atrium) that receive blood returning to the heart.

Capillaries: Smallest blood vessels where oxygen and nutrients are exchanged for waste products with tissues.

Cardiac cycle: Sequence of events that occur with each heartbeat, including systole (contraction) and diastole (relaxation) of the heart chambers.

Coronary arteries: Blood vessels that supply oxygen and nutrients to the heart muscle itself.

Diastole: The phase of the cardiac cycle when the heart chambers (ventricles) relax and fill with blood.

Endocardium: Innermost layer of the heart's wall, lining the heart chambers and providing a smooth surface for blood flow.

Endothelium: Inner lining of blood vessels, which plays a role in regulating blood flow and preventing clot formation.

Heart chambers: Atria: Upper chambers of the heart that receives blood.

Ventricles: Lower chambers of the heart responsible for pumping blood to the lungs and the rest of the body.

Heart valves: Atrioventricular (AV) valves: Valves that separate the atria from the ventricles; includes the tricuspid and mitral (bicuspid) valves.

Semilunar valves: Valves located at the exits of the heart; includes the aortic and pulmonary valves.

Myocardium: Middle layer of the heart's wall, consisting of muscle tissue responsible for the heart's pumping action.

Pericardium: Sac-like membrane that surrounds and protects the heart.

Pulmonary artery: Carries deoxygenated blood from the right ventricle of the heart to the lungs for oxygenation.

Pulmonary veins: Carry oxygenated blood from the lungs back to the left atrium of the heart.

Systole: The phase of the cardiac cycle when the heart chambers (ventricles) contract and eject blood.

Veins: Blood vessels that return deoxygenated blood from the body's tissues and organs back to the heart.

Vena cava (superior and inferior): Largest veins in the body, which return deoxygenated blood from the upper and lower parts of the body to the right atrium of the heart.

Ventricles: Lower chambers of the heart responsible for pumping blood; includes the right ventricle and left ventricle.

Ventricular septum: The wall that separates the right and left ventricles of the heart.

Venules: Small veins that collect blood from capillaries and merge to form larger veins.

MULTIPLE CHOICE QUESTIONS

1. Which chamber of the heart pumps oxygenated blood to the systemic circulation?
a) Left atrium
b) Right atrium
c) Left ventricle
d) Right ventricle

2. What is the main function of the atria in the heart?
a) Pumping blood to the lungs
b) Pumping blood to the body
c) Receiving blood from the body and lungs
d) Preventing backflow of blood

3. Which blood vessels carry oxygenated blood?
   a) Arteries
   b) Veins
   c) Capillaries
   d) Venules

4. What is the primary function of the coronary arteries?
   a) Carry deoxygenated blood away from the heart
   b) Supply oxygen and nutrients to the heart muscle
   c) Transport blood from the lungs to the heart
   d) Regulate blood pressure

5. During which phase of the cardiac cycle does the heart relax and fill with blood?
   a) Systole
   b) Diastole
   c) Atrioventricular phase
   d) Semilunar phase

6. Which blood vessel carries deoxygenated blood from the right ventricle to the lungs?
   a) Aorta
   b) Pulmonary artery
   c) Pulmonary vein
   d) Superior vena cava

7. What is the term for the phase of the cardiac cycle when the ventricles contract and eject blood?
   a) Systole
   b) Diastole
   c) Atrial depolarization
   d) Ventricular relaxation

8. What is the primary function of capillaries in the circulatory system?
   a) Pump blood to the body's organs
   b) Exchange gases and nutrients with tissues
   c) Prevent backflow of blood
   d) Store excess blood

9. What condition is characterised by the buildup of fatty deposits in the arterial walls?
   a) Atherosclerosis
   b) Hypertension
   c) Angina pectoris
   d) Bradycardia

10. What is the condition characterised by the heart's inability to pump blood effectively?
    a) Bradycardia
    b) Hypertension
    c) Heart failure
    d) Angina pectoris

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