

CARDIAC PHYSIOLOGY

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*The human heart is a vital organ responsible for maintaining continuous blood circulation, delivering oxygen and nutrients to tissues, and removing metabolic wastes. Cardiac physiology encompasses the study of the heart's structure, electrical conduction system, and functional dynamics, including the cardiac cycle, heart rate, stroke volume, and cardiac output. The heart's efficiency relies on the coordinated interaction between its chambers, valves, and conduction pathways, as well as regulatory influences from the autonomic nervous system and hormones. Coronary circulation ensures the myocardium receives adequate oxygen and nutrients, while feedback mechanisms help maintain cardiovascular homeostasis under varying physiological conditions. Understanding heart physiology is essential for comprehending normal biological processes and for the prevention, diagnosis, and treatment of cardiovascular disorders*

**Introduction:** The human heart is a vital organ that serves as the central component of the circulatory system, responsible for maintaining the continuous flow of blood throughout

the body. Its primary function is to deliver oxygen and essential nutrients to tissues and organs while removing carbon dioxide and metabolic wastes. The heart's intricate structure, comprising four chambers—two atria and two ventricles—enables it to perform this function efficiently. Blood flows through a coordinated pathway: deoxygenated blood enters the right atrium, moves to the right ventricle, and is pumped to the lungs for oxygenation, while oxygen-rich blood returns to the left atrium, passes into the left ventricle, and is circulated throughout the body.

Cardiac activity is regulated by a sophisticated conduction system, including the sinoatrial (SA) node, atrioventricular (AV) node, bundle of His, and Purkinje fibers. This system ensures rhythmic contraction and relaxation, supporting unidirectional blood flow and optimal cardiac output. Factors such as heart rate, stroke volume, autonomic nervous system regulation, and hormonal influences interact to maintain cardiovascular stability under varying physiological conditions.

Understanding heart physiology is essential not only for comprehending fundamental biological processes but also for diagnosing and managing cardiovascular disorders. This study provides an overview of the heart's structural and functional characteristics, highlighting the mechanisms that sustain life through effective circulation.

The human heart is a remarkable organ, central to the circulatory system and essential for sustaining life. Functioning primarily as a muscular pump, it ensures that oxygen-rich blood is delivered to tissues and organs while simultaneously transporting carbon dioxide and metabolic wastes to excretory organs for removal. Structurally, the heart is composed of four chambers: two atria and two ventricles. The right atrium receives deoxygenated blood from the body through the superior and inferior vena cavae, directing it into the right ventricle, which then pumps the blood to the lungs via the pulmonary artery for oxygenation. Conversely, the left atrium receives oxygenated blood from the lungs through the pulmonary veins and channels it into the left ventricle, which is responsible for pumping blood throughout the systemic circulation. The left ventricle, with its thick muscular walls, generates the high pressure needed to propel blood efficiently to distant organs.

The cardiac cycle is a coordinated sequence of electrical and mechanical events that ensures unidirectional blood flow. It consists of two primary phases: systole, the contraction phase, and diastole, the relaxation phase. During systole, the ventricles contract, causing the atrioventricular valves to close, which prevents backflow, while the semilunar valves open to allow blood to be ejected into the arteries. Diastole follows, during which the heart

muscle relaxes, allowing the chambers to fill with blood in preparation for the next contraction. This rhythmic alternation is regulated by the heart's intrinsic conduction system, which includes the sinoatrial (SA) node, atrioventricular (AV) node, bundle of His, and Purkinje fibers. The SA node, often referred to as the natural pacemaker, initiates electrical impulses that spread throughout the atria, leading to coordinated atrial contraction. Impulses then pass to the AV node, which introduces a brief delay, ensuring that the ventricles fill completely before contracting.

Cardiac output, defined as the volume of blood pumped by the heart per minute, is a key indicator of cardiovascular function. It is influenced by heart rate and stroke volume, the amount of blood ejected by the ventricles with each beat. Various factors, including autonomic nervous system activity, hormones, and physical activity, modulate heart rate and contractility. The sympathetic nervous system increases heart rate and the force of contraction, preparing the body for heightened activity, while the parasympathetic nervous system reduces heart rate during restful states. Additionally, circulating hormones such as adrenaline and noradrenaline enhance cardiac performance during stress or exercise.

The heart is also highly responsive to metabolic demands of the body. During exercise or periods of increased demand, cardiac output rises significantly to ensure adequate oxygen delivery to skeletal muscles. This adaptation is supported by the Frank-Starling mechanism, which relates the degree of myocardial stretch during diastole to the force of subsequent contraction. A greater venous return stretches the ventricular walls, resulting in more forceful contractions and higher stroke volume, thus meeting the body's increased metabolic requirements. Coronary circulation provides the heart muscle itself with oxygen and nutrients essential for continuous functioning. The coronary arteries branch from the aorta and supply the myocardium, while the coronary veins return deoxygenated blood to the right atrium. Impairments in coronary blood flow can lead to ischemia, myocardial infarction, or other cardiovascular disorders, highlighting the importance of maintaining cardiovascular health.

The heart's physiology is not isolated but integrated with the overall circulatory system and other organ systems. Baroreceptors and chemoreceptors detect changes in blood pressure and chemical composition, relaying information to the brain to modulate cardiac function and maintain homeostasis. The intricate coordination between electrical impulses, mechanical contraction, and vascular feedback ensures that the body's tissues receive a continuous and adequate supply of oxygen and nutrients.



**Conclusion:** The human heart is a highly specialized and efficient organ that plays a central role in sustaining life by ensuring continuous blood circulation. Its complex structure, consisting of four chambers and an intricate network of valves, works in harmony with the heart's electrical conduction system to maintain rhythmic contractions and unidirectional blood flow. Cardiac output, influenced by heart rate and stroke volume, is finely regulated by neural and hormonal mechanisms to meet the body's changing metabolic demands.

The heart's ability to adapt to various physiological conditions, such as exercise or stress, demonstrates its remarkable resilience and functional versatility. Coronary circulation ensures that the myocardium receives sufficient oxygen and nutrients to maintain its activity, while feedback systems involving baroreceptors and chemoreceptors help preserve cardiovascular homeostasis. Understanding cardiac physiology is crucial for medical practice, as it provides the foundation for diagnosing, treating, and preventing heart-related disorders. Overall, the study of heart physiology highlights the delicate balance and coordination required to sustain life, emphasizing the importance of maintaining cardiovascular health.

In conclusion, the human heart is a complex, highly efficient organ that plays a pivotal role in maintaining life. Its structure and function are intricately designed to sustain continuous blood flow, adapt to changing physiological demands, and support the dynamic requirements of the body. Understanding cardiac physiology not only provides insight into fundamental biological processes but also informs medical practice, guiding interventions to preserve cardiovascular health and treat heart-related disorders.

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