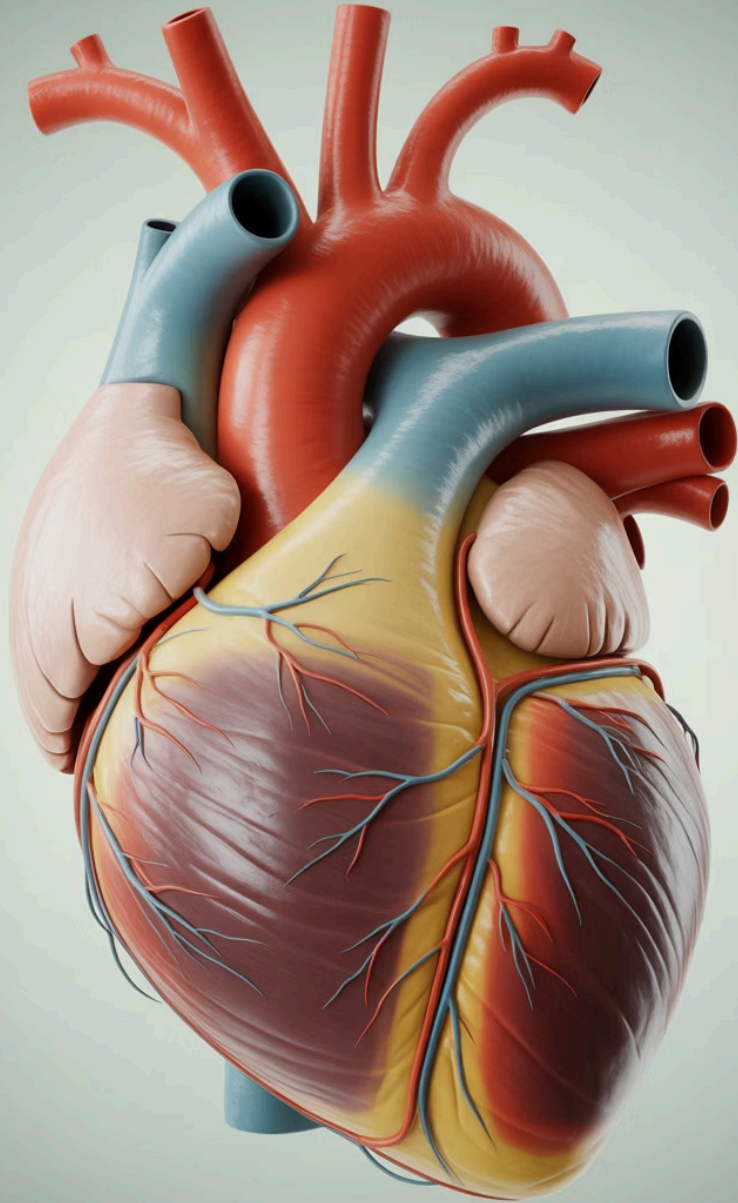




The Heart and Circulatory System

The Circulatory System: A One-Way Network

The circulatory system is a sophisticated transport network ensuring blood flows in only one **direction**, preventing **backflow** and maintaining **efficient** circulation. It comprises blood **vessels**, a powerful **pump** (the heart), and strategically positioned **valves**.

One-way valves act as biological gates, opening to allow blood through and closing to prevent any backward movement.

Heart drives circulation.

Vessels: transport pathways.

Valves ensure one way blood flow.



Pump

Heart drives circulation



Vessels

Transport pathways



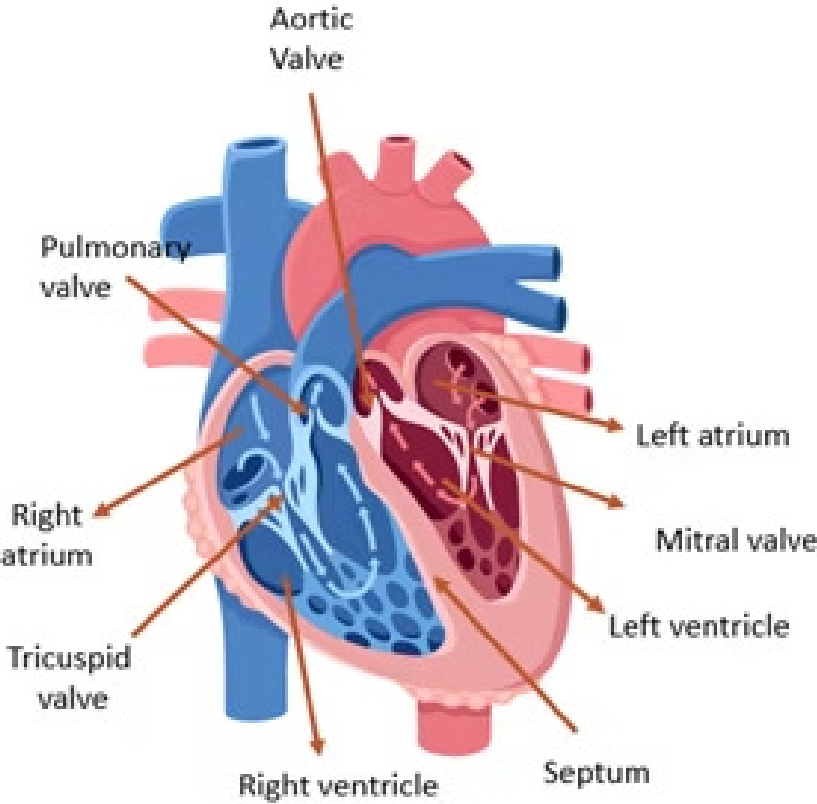
Valves

Ensure one-way flow

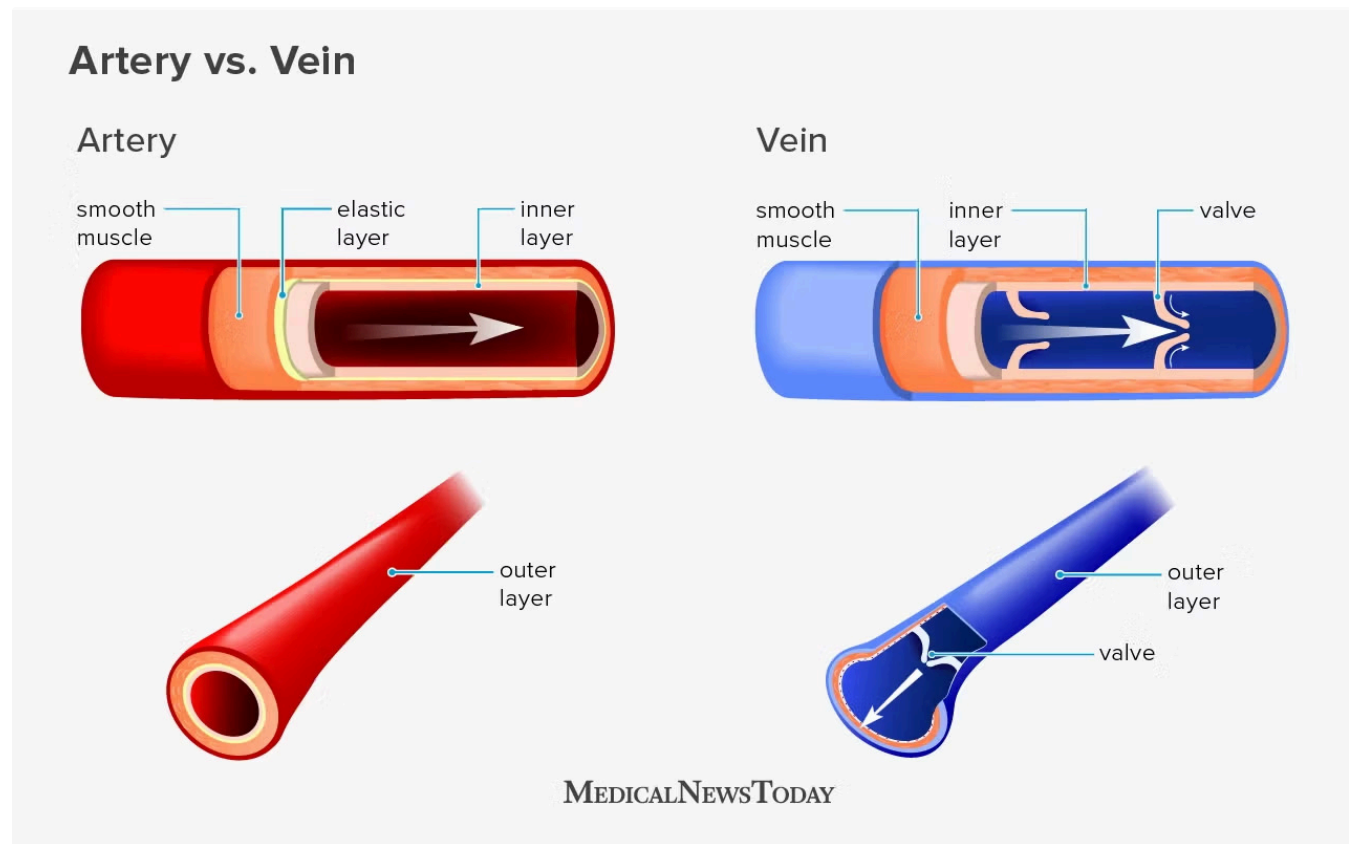
Anatomy of the Mammalian Heart

The mammalian heart is a muscular organ divided into four chambers. The **upper** chambers, called **atria** (singular: atrium), receive **blood returning** to the **heart**. The **lower** chambers, called **ventricles**, **pump blood** out of the heart. A thick muscular **wall** called the **septum** separates the **left** and **right** sides, preventing **oxygen**-rich and **oxygen**-poor blood from **mixing**.

	Muscular Wall Thick cardiac muscle tissue contracts to pump blood throughout the body with sufficient force
	Septum Central dividing wall that separates left and right sides, maintaining two separate circuits
	Atria & Ventricles Four chambers: left and right atria receive blood, left and right ventricles pump it out
	One-Way Valves Prevent backflow between chambers and into major vessels, ensuring efficient circulation
	Coronary Arteries Supply the heart muscle itself with oxygen and nutrients essential for continuous function



Blood Flow: Arteries and Veins



Arteries

Arteries carry blood **away from the heart** under high pressure. Their thick, muscular, elastic walls withstand and maintain this pressure. The largest artery, the aorta, branches into smaller arteries that deliver oxygenated blood to all body tissues.

Veins

Veins return blood **to the heart** under low pressure. Their thinner walls and larger internal diameter accommodate slower blood flow. Veins contain valves that prevent backflow, aided by skeletal muscle contractions that squeeze blood towards the heart.

Monitoring Heart Activity

Medical professionals monitor heart activity using several different methods, each providing valuable information about cardiovascular health. These techniques help diagnose problems and assess overall heart function.



Electrocardiogram (ECG)

Records electrical activity of the heart as waves on a graph, detecting irregular rhythms and damage to heart muscle



Pulse Rate

Measures how many times the heart beats per minute by feeling arterial pulsations, typically at the wrist or neck



Listening to Valve Sounds

Using a stethoscope to hear valves closing helps identify problems like valve leakage or narrowing of chambers

Physical Activity and Heart Rate



Why Does Heart Rate Increase?

During physical activity, muscles require significantly more oxygen and glucose to produce energy for contraction. Simultaneously, they generate increased amounts of carbon dioxide as waste that must be removed.

The heart responds by beating faster and more forcefully, increasing blood flow to deliver more oxygen and nutrients whilst removing carbon dioxide more efficiently. This increased cardiac output ensures active muscles receive adequate supplies to sustain their work.

After exercise ceases, heart rate gradually returns to resting levels as oxygen demand decreases and waste products are cleared from muscle tissue.

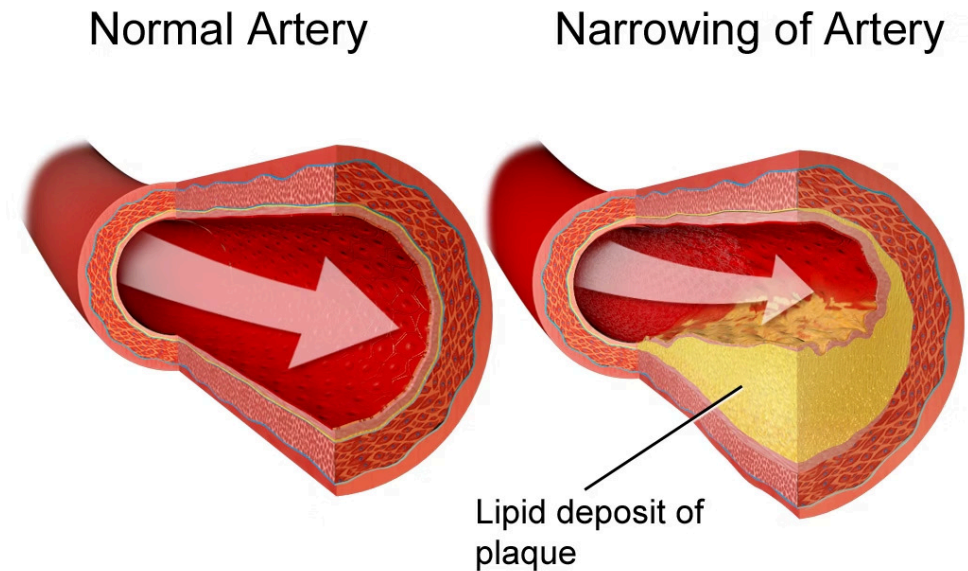
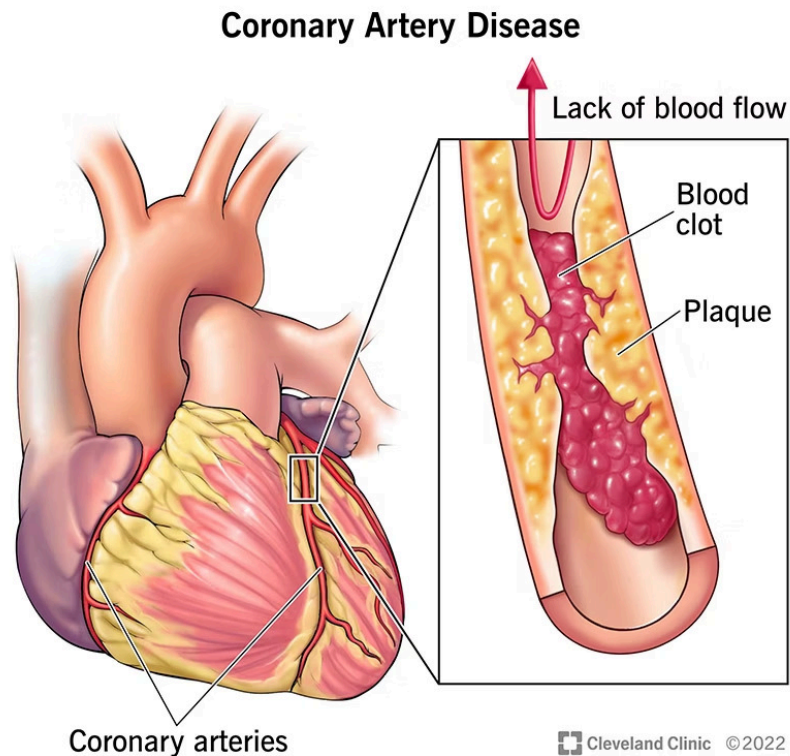
Investigation: Exercise Effect

When you measure pulse rate before, during, and after physical activity, a clear pattern emerges. Resting heart rate typically ranges from 60–100 beats per minute, but during vigorous exercise, it can increase to 150–200 beats per minute.

Coronary Heart Disease

Coronary heart disease (CHD) occurs when the coronary **arteries**—blood vessels supplying the heart muscle itself—become **narrowed** or **blocked**. This happens due to the **gradual build-up of fatty deposits** called **plaques** on the artery **walls**, a process known as atherosclerosis. As plaques **accumulate**, they reduce **blood** flow to heart **muscle**, potentially causing chest pain (**angina**) or, if an artery becomes completely **blocked**, a **heart attack**.

When heart muscle is deprived of oxygen-rich blood, cells begin to die, resulting in permanent damage. The severity depends on which coronary artery is affected and how quickly treatment is received.



Coronary Artery Disease

Risk Factors for Coronary Heart Disease

Diet

High intake of saturated fats, salt, and processed foods increases cholesterol levels and blood pressure, promoting plaque formation in arteries

Lack of Exercise

Physical inactivity weakens the heart muscle, promotes weight gain, and increases risk of high blood pressure and unhealthy cholesterol levels

Stress

Chronic stress raises blood pressure and may lead to unhealthy coping behaviours such as overeating, smoking, or insufficient sleep

Smoking

Tobacco damages artery linings, increases blood clotting, raises blood pressure, and reduces oxygen-carrying capacity of blood

Genetic Predisposition

Family history of heart disease increases personal risk, as certain genes affect cholesterol metabolism and blood pressure regulation

Age and Sex

Risk increases with age; men face higher risk at younger ages, whilst women's risk increases significantly after menopause

Reducing Risk Through Lifestyle



The Role of Diet

A heart-healthy diet significantly reduces CHD risk by managing cholesterol and blood pressure. Increasing consumption of fruits, vegetables, whole grains, and oily fish provides essential nutrients and healthy fats that protect arteries.

Reducing intake of saturated fats (found in red meat and dairy), trans fats (in processed foods), and excessive salt helps prevent plaque build-up and maintains healthy blood pressure levels. Limiting refined sugars also helps control weight and reduces diabetes risk—itsself a significant CHD risk factor.



The Role of Exercise

Regular physical activity strengthens the heart muscle, enabling it to pump blood more efficiently with less effort. Exercise raises levels of HDL cholesterol (the "good" type) whilst lowering harmful LDL cholesterol and triglycerides.

Aim for at least 150 minutes of moderate-intensity activity weekly—such as brisk walking, cycling, or swimming. Exercise also helps maintain healthy weight, reduces blood pressure, improves blood sugar control, and reduces stress—all factors that lower CHD risk substantially.

Combined Impact: When diet and exercise work together, their protective effects multiply. Studies show that individuals who maintain both healthy eating habits and regular physical activity reduce their CHD risk by up to 80% compared to those with sedentary lifestyles and poor diets.

Structure of Blood Vessels

Arteries, veins, and capillaries each have distinct structural features tailored to their specific roles in the circulatory system. These differences are crucial for efficient blood transport and exchange.



Arteries

Possess **thick, muscular**, and **elastic** walls to withstand the **high pressure** of blood **from** the heart. They have a relatively **narrow lumen** and contain no **internal valves**.

Small lumen = high pressure.



Veins

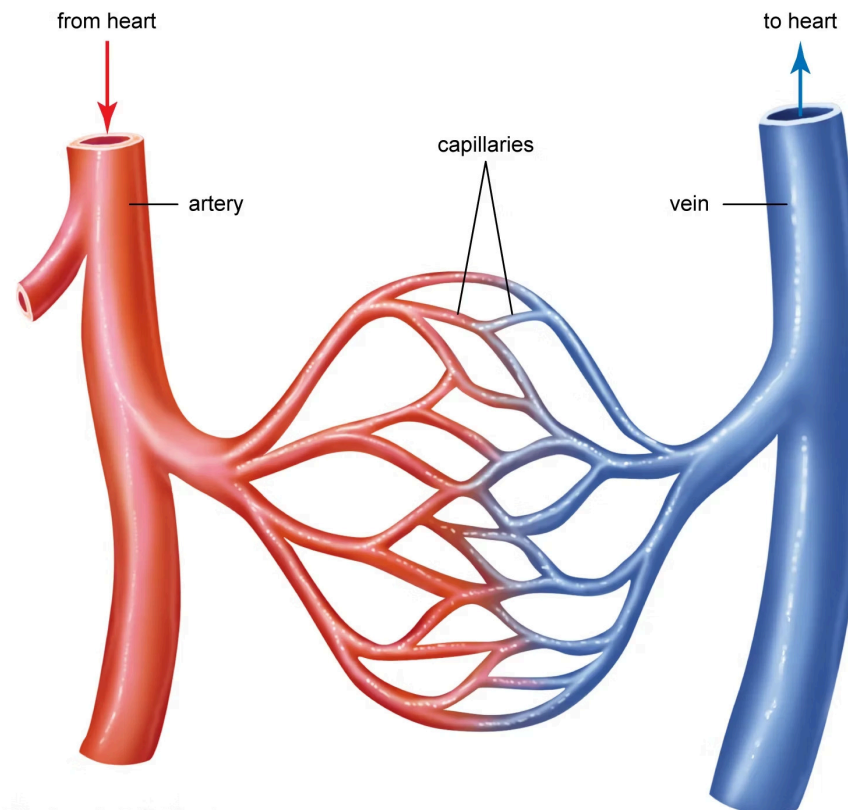
Feature **thinner**, less **muscular** walls and a **wider** lumen compared to arteries. Crucially, veins contain semi-lunar **valves**, particularly in the limbs, to prevent **blood from flowing** backwards against **gravity**.

Wide lumen = low pressure



Capillaries

Are the **smallest** blood vessels, with walls only **one cell thick**, enabling rapid exchange of substances. They have an **extremely narrow** lumen, allowing red blood cells to pass in **single file**, and no **valves**.



Arteries and Veins: Pressure Adaptations

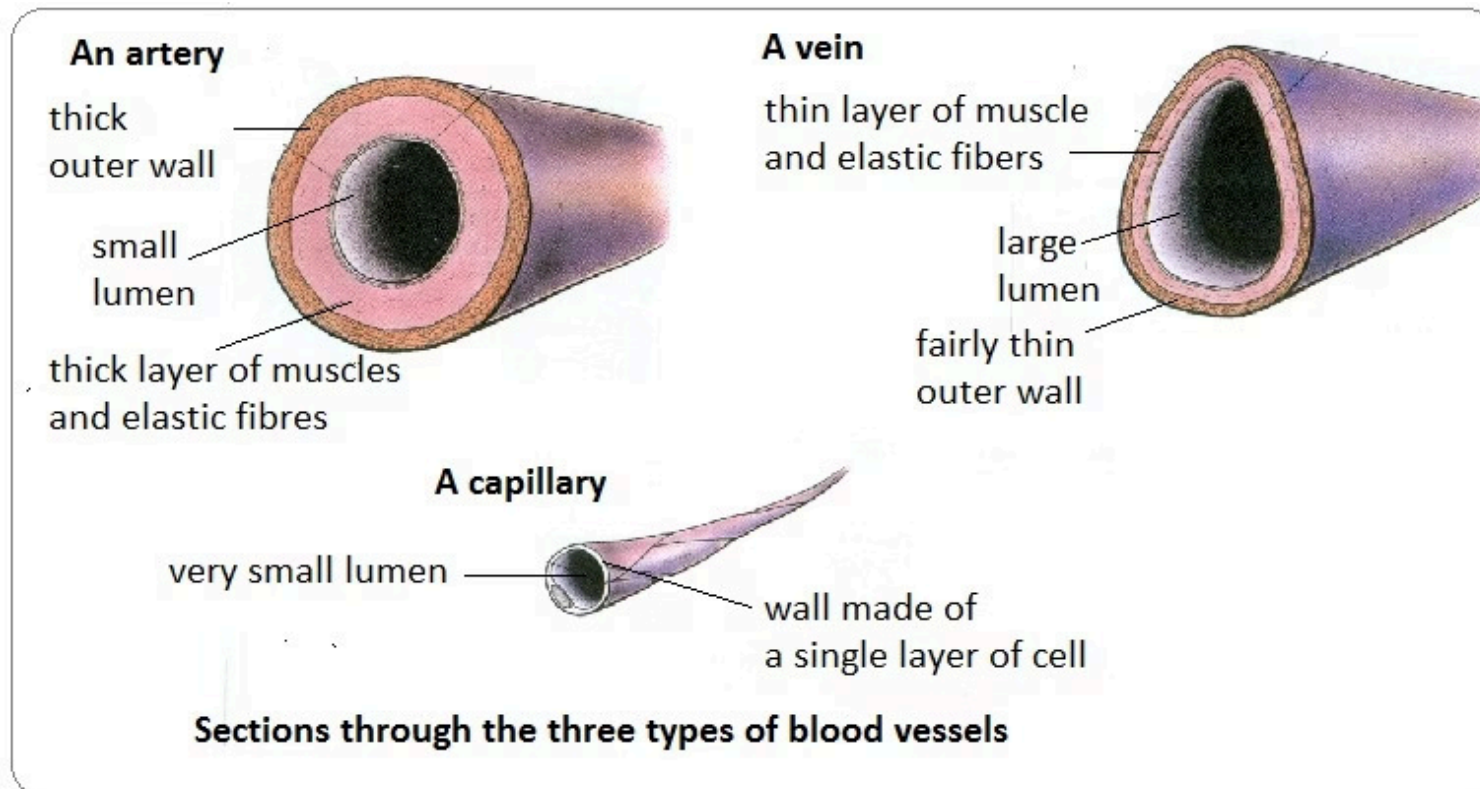
The distinct structures of arteries and veins are perfectly engineered to handle the varying blood pressures they encounter throughout the circulatory system.

Arteries: Built for High Pressure

Arteries receive blood directly from the heart, enduring high pressure. Their thick, muscular, and elastic walls expand and recoil with each heartbeat, maintaining blood flow and preventing rupture. The narrow lumen helps sustain this pressure, driving blood efficiently throughout the body.

Veins: Designed for Low Pressure

Veins transport blood back to the heart, where pressure is significantly lower. Their walls are thinner and less muscular, and they have a wider lumen to reduce resistance. To counteract gravity, especially in limbs, veins contain one-way valves that prevent blood from flowing backward.



Components of Blood

Blood is a vital fluid made up of several key components, each with a unique role in maintaining bodily functions and health.



Red Blood Cells

These biconcave discs are responsible for transporting oxygen from the lungs to the body's tissues and carbon dioxide back to the lungs. They contain haemoglobin, which gives blood its red colour.



White Blood Cells

Part of the immune system, white blood cells (leukocytes) identify and destroy foreign invaders like bacteria and viruses. There are several types, each with specialised protective functions.



Platelets

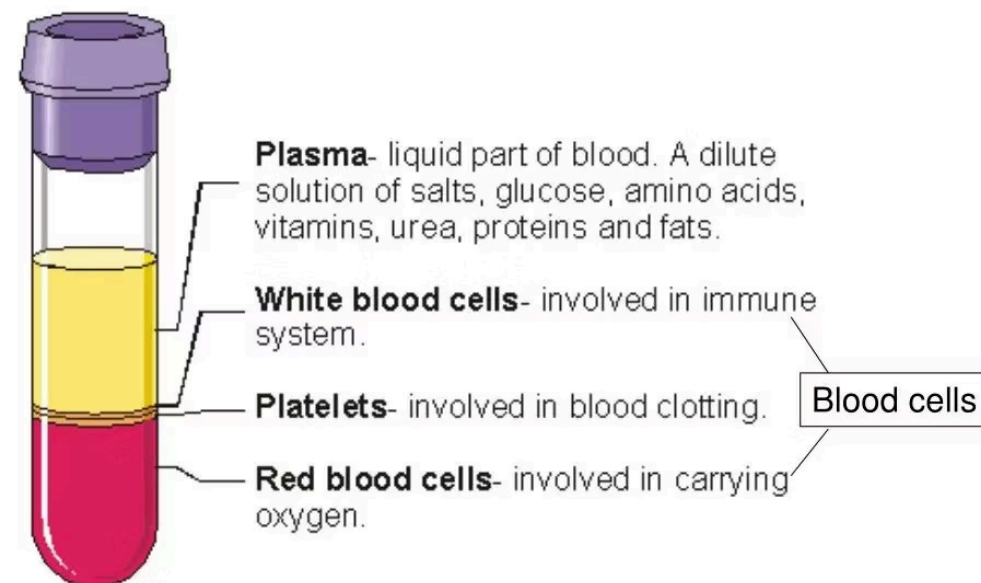
These small, irregularly shaped cell fragments are crucial for blood clotting. When a blood vessel is damaged, platelets aggregate at the site to form a plug, preventing excessive blood loss.



Plasma

The liquid component of blood, plasma makes up about 55% of its total volume. It carries blood cells, nutrients, hormones, proteins, and waste products throughout the body.

Four main components in blood



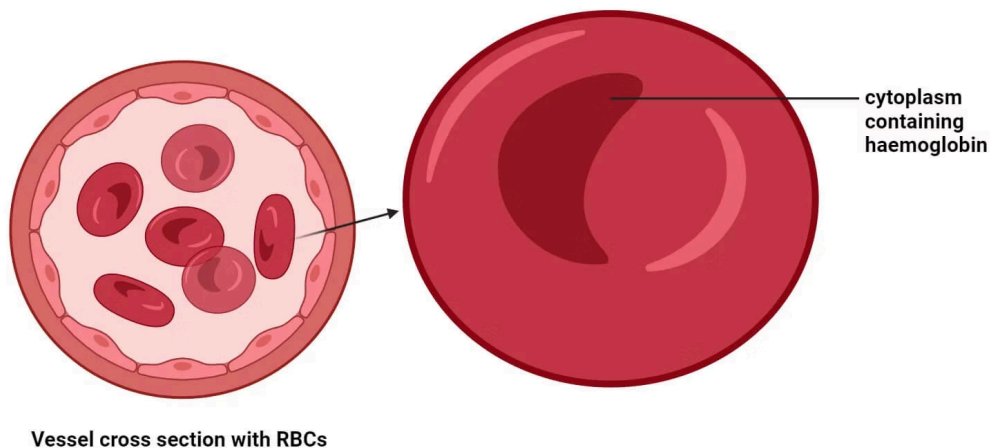
Identifying Red and White Blood Cells

Distinguishing between red and white blood cells under a microscope is fundamental to understanding blood composition and diagnosing various conditions. Their distinct structural features make them readily identifiable.

Red Blood Cells (Erythrocytes)

These are the most abundant cells in the blood, easily recognized by their uniform, biconcave disc shape. Mature red blood cells lack a nucleus, giving them a clear central area under magnification. Their characteristic red colour is due to the presence of haemoglobin, essential for oxygen transport.

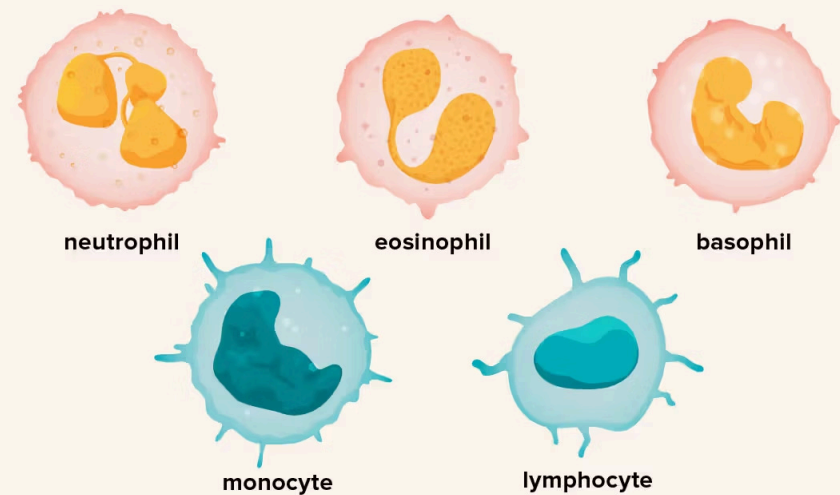
Structure of RBC



White Blood Cells (Leukocytes)

White blood cells are larger and significantly less numerous than red blood cells. A key feature is the presence of a distinct nucleus, which can vary in shape (lobed, kidney-shaped, or round) depending on the leukocyte type. Their cytoplasm may appear clear or granular, reflecting their diverse roles in the immune system.

FIVE TYPES OF WHITE BLOOD CELLS



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Roles of Blood Clotting

Blood clotting, also known as coagulation, is a vital physiological process with dual protective functions that are essential for maintaining health and preventing serious complications from injury.



Preventing Blood Loss

When a blood vessel is damaged, platelets rapidly aggregate at the site of injury. These platelets then release chemical factors that initiate a cascade, leading to the formation of a fibrin mesh. This mesh traps red blood cells and more platelets, forming a stable clot that seals the wound and prevents excessive haemorrhage.



Blocking Pathogen Entry

Beyond its role in haemostasis, the blood clot forms a critical physical barrier that isolates the internal environment from potential external threats. This barrier prevents harmful microorganisms, such as bacteria, viruses, and fungi, from entering the bloodstream through an open wound, significantly reducing the risk of systemic infection.

