VASCULAR SYSTEM

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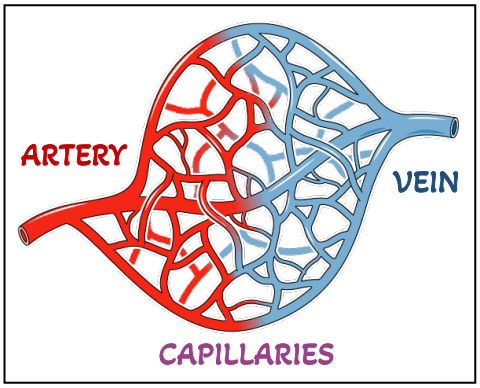
CIRCULATORY SYSTEM

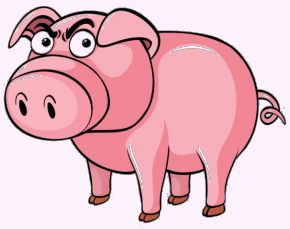
The circulatory system is composed of a closed network of vessels that move materials around the body. These materials are moved within a fluid called blood and the movement of blood is driven by the action of a muscular heart. The blood is transported at high pressure from the heart via **arteries**, which become split to form smaller *arterioles*. These arterioles then branch into **capillaries** that function as the site of material exchange with the body tissues. The capillaries then pool into *venules*, which converge to form **veins**. The veins then act to return the blood back to the heart at low pressure.



BLOOD

Blood is the fluid medium in which materials are transported around the body. The blood contains three types of cells that each perform a specific function – **red blood cells** (erythrocytes) transport oxygen to the tissues, **white blood cells** (leukocytes) fight off pathogenic infections and **platelets** (thrombocytes) are used in clotting. The fluid component of blood is called *plasma* and is involved in transporting many materials:

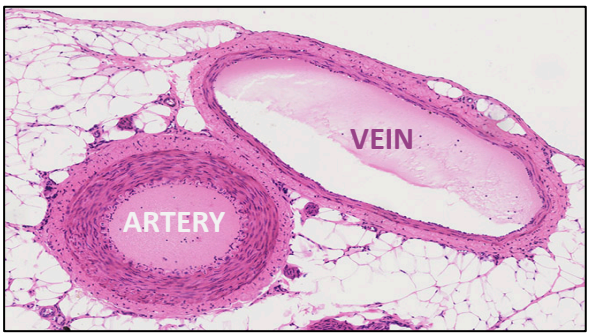
- **H**ormones (chemical messengers)
- **U**rea (nitrogenous waste product)
- **G**ases (oxygen and carbon dioxide)
- **E**lectrolytes (minerals and ions)
- **P**lasma proteins (e.g. albumin)
- **I**mmunoglobulins (antibodies)
- **G**lucose (and other nutrients)
- **S**olvent (water as a medium)



VESSELS

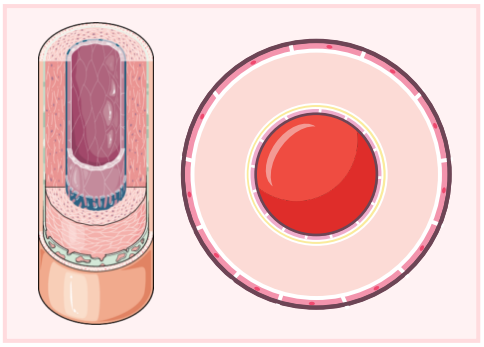
Blood is transported in three types of vessels – all of which have distinctive morphologies according to their main role:

- Arteries have thick walls and comparably narrow lumen (this is because the blood is moving at a high pressure)
- Veins have thinner walls and an extremely wide lumen (as the blood is returning to the heart at low pressure)
- Capillaries are very small (site of material exchange)



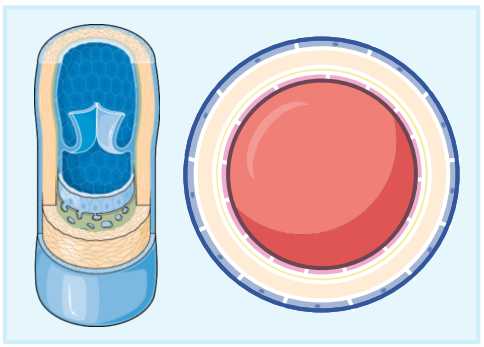
ARTERIES

Arteries function to transport blood *from* the heart at **high pressure** and have specialised structures to accomplish this. They have a thick wall composed of an outer layer of collagen, which acts to prevent the artery from rupturing under the high pressures. The inner layer of the arterial wall consists of muscle and elastic fibres, which can stretch and recoil with each pulse of blood to help maintain a stable blood pressure between pump cycles. The lumen is comparatively narrow compared to a vein, which functions to keep pressure high.



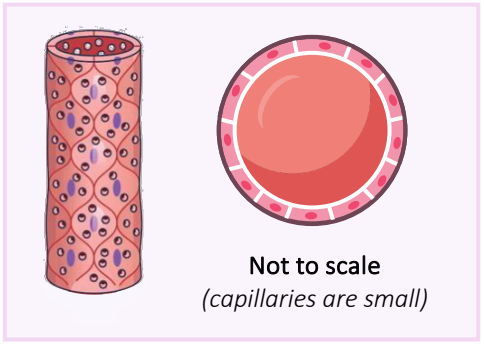
VEINS

Veins act to transport the blood *towards* the heart at **low pressure** and have specialised structures to accomplish this. The wall is much thinner because blood pressure is lower (less chance of rupturing), however, the lumen is much wider (optimising the return of blood). The muscle and elastic fibres in the vessel wall provide flexibility, allowing veins to be compressed by skeletal muscle contractions (which helps to propel blood back towards the heart). Because the pressure is low, veins have **valves** to prevent the backflow of blood.



CAPILLARIES

Capillaries function as the site of **material exchange** with tissues. The pressure in capillaries is low, due to the repeated branching of arteries. The lumen is extremely narrow, with only one erythrocyte able to pass through a capillary at a time – optimising the exchange of oxygen with the tissues. The wall of a capillary is extremely thin (composed of a single layer of endothelial cells), which minimises the diffusion distance between the blood and the interstitial fluid. Capillaries *may* be **fenestrated** (contain pores) to improve transfer.



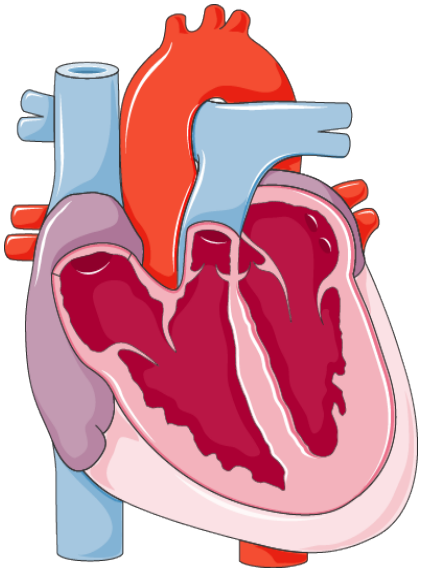
BLOOD VESSEL COMPARISON

The differences between the three types of blood vessels can be summarised by the following table:

	Arteries	Veins	Capillaries
Function	Transports blood **from** the heart	Transports blood **towards** the heart	The site of material exchange
Blood Pressure	High (80 – 120 mmHg)	Very low (>10 mmHg)	Low (~15 mmHg)
Lumen Diameter	Narrow	Wide	Extremely narrow
Wall Thickness	Thick (three tissue layers)	Thin (three tissue layers)	Extremely thin (single cell layer)
Elastic Fibres	Large amounts	Small amounts	None
Valves	None	Present	None

HEART

The human heart is a four chambered organ, consisting of two atria and two ventricles. **Atria** act as reservoirs, by which blood returning to the heart (via veins) is collected and passed on to the ventricles. The **ventricles** then act as pumps, expelling the blood (via arteries) to the various body tissues. The heart can be functionally divided into two sides. The right side of the heart collects the deoxygenated blood from the body tissues and pumps it to the lungs *(pulmonary circulation)*. The left side of the heart then collects the oxygenated blood from the lungs and pumps it to all the body tissues *(systemic circulation)*. The left side of the heart has a thicker muscular lining (myocardium) because it needs to pump blood greater distances. Hearts are drawn as they would appear when looking at a chest – so, the left side of a drawing represents the right side of the heart.



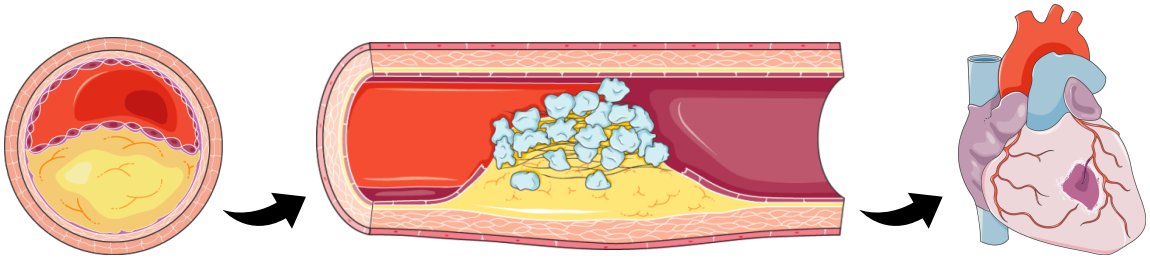
HEART RATE

Blood circulates around the body as a consequence of the rhythmic contraction of the heart. Each of these contractions (or heart beats) forces a wave of blood through the arteries, which can be detected as a **pulse**. The heart rate is monitored by the medulla oblongata (brainstem) and can be regulated by either nervous impulses or hormonal signals (specifically adrenaline). Heart rate can be affected by a range of conditions, including physical activity (exercise), age, specific diseases, body temperature and emotional states (stress).

CORONARY HEART DISEASE

The blood that is being pumped through the heart cannot be used to supply the heart tissue with oxygen or glucose. This function is achieved by a network of vessels surrounding the heart – called **coronary arteries**. If a coronary artery becomes occluded, then the heart tissue that is nourished by the blocked artery begins to die, resulting in the eventual development of coronary heart disease (CHD) and a potential heart attack.

Atherosclerosis is the hardening and narrowing of arteries due to the deposition of cholesterol. When fatty deposits (atheromas) develop in the arteries, the lumen diameter becomes greatly reduced. The restricted blood flow increases pressure in the artery, leading to damage to the arterial wall and the development of fibrous lesions called atherosclerotic plaques. If a plaque ruptures, blood clotting is triggered, forming a **thrombus** which restricts blood flow. The formation of a thrombus within a coronary artery leads to CHD.



A variety of factors can increase the risks of developing occlusions in the coronary arteries, including:

- **Genetics** – hypertension may increase risks
- **Obesity** – being overweight strains the heart
- **Diseases** – diabetes can increase the risks
- **Diet** – salty and fat-rich diets pose a threat
- **Exercise** – sedentary lifestyles are dangerous
- **Sex** – males are at greater risk (less estrogen)
- **Smoking** – nicotine causes vasoconstriction
- **Age** – the risks generally increase with age