

Transport in animals

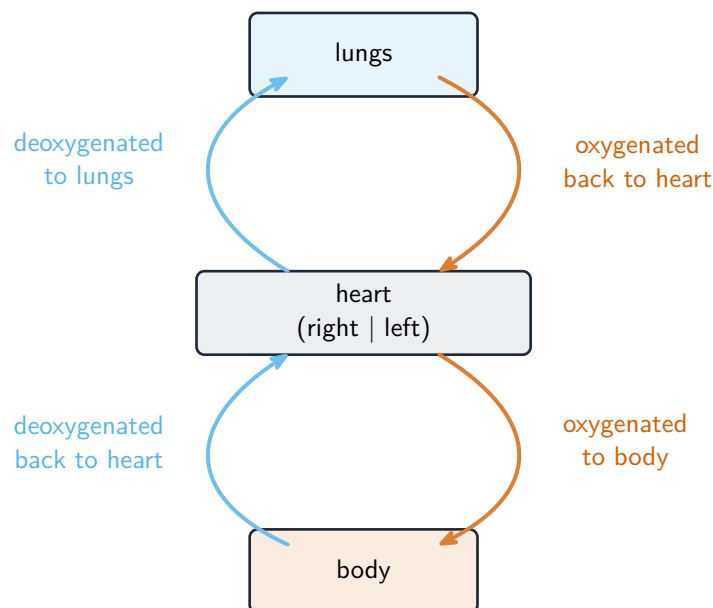
IGCSE Biology

The circulatory system

The **circulatory system** 循环系统 carries blood around the body. It has three parts: a **pump** 泵 (the **heart** 心脏), a network of **blood vessels** 血管, and **valves** 瓣膜 that keep the blood flowing one way only.

Single and double circulation (Supplement)

- A fish has a **single circulation** 单循环: the blood passes through the heart **once** on each trip around the body.
- A **mammal** 哺乳动物 has a **double circulation** 双循环: the blood passes through the heart **twice** on each full trip —once on the way to the lungs, and once on the way to the rest of the body.
- The advantage of a double circulation: the blood can be pumped again at **high pressure** 压力 before going to the body, so it travels faster and delivers **oxygen** 氧气 quickly.



In a double circulation, blood passes through the heart twice on each trip round the body

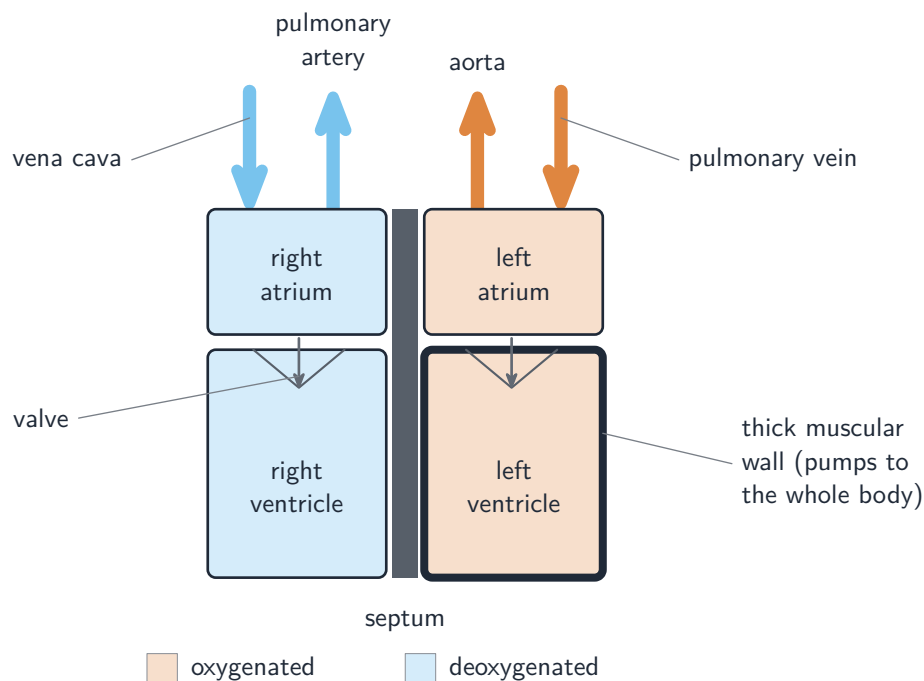
The heart

The heart is made of **muscle** 肌肉. A wall called the **septum** 隔膜 divides it into a left side and a right side. On each side there is an upper chamber, the **atrium** 心房, and a lower chamber, the **ventricle** 心室. Valves between the chambers stop the blood flowing backwards. The heart muscle is fed with blood by the **coronary arteries** 冠状动脉.

(Supplement) The wall of the left ventricle is thicker than the right, because it must pump blood all the way around the body; the right side only pumps blood to the nearby lungs. The atria have thin walls, as they only push blood into the ventricles just below them.

The septum keeps **oxygenated blood** 含氧血 on the left side apart from **deoxygenated blood** 缺氧血 on the right side, so the two never mix.

(Supplement) The valves between each atrium and ventricle are the **atrioventricular valves** 房室瓣. The valves at the exit of each ventricle are the **semilunar valves** 半月瓣.



The heart's four chambers; the left ventricle has the thickest wall, to pump to the whole body

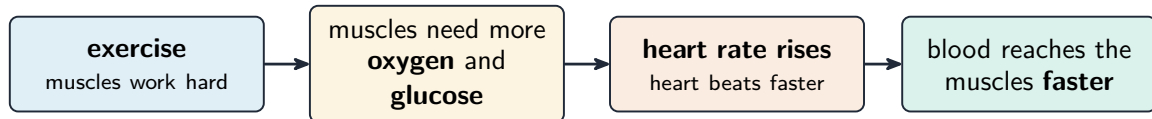
How the heart beats (Supplement)

1. The atria **contract** 收缩 and push blood down into the ventricles.
2. The ventricles contract and force blood out into the arteries; the valves snap shut so blood cannot flow back.
3. The muscle relaxes and the heart fills with blood again.

Blood is pumped away from the heart in arteries and returns to the heart in veins.

Heart rate and exercise

You can check the heart's activity with an **ECG**, by feeling the **pulse** 脉搏 in an artery, or by listening to the valves closing. During exercise the **heart rate** 心率 goes up, so blood reaches the muscles faster, bringing the extra oxygen and glucose they need.



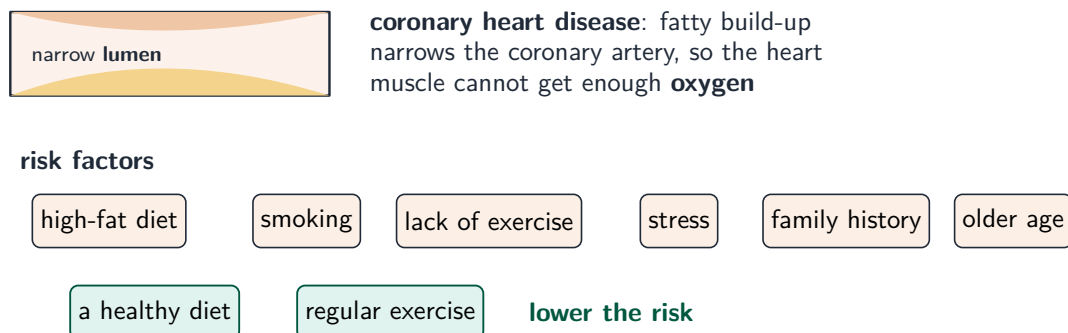
check the heart's activity by feeling the **pulse**, listening to the valves, or with an **ECG**

During exercise the heart rate rises so blood reaches the muscles faster

Worked example. A student counts 18 pulse beats in 15 seconds at rest, and 33 beats in 15 seconds straight after exercise. Give both heart rates in beats per minute. A minute holds $60 \div 15 = 4$ lots of 15 seconds, so multiply by 4. At rest: $18 \times 4 = \mathbf{72 \text{ beats per minute}}$. After exercise: $33 \times 4 = \mathbf{132 \text{ beats per minute}}$. The rise delivers more oxygen and glucose to the muscles. Writing the 15-second count straight down as the heart rate is the commonest mistake - always scale it up to a full minute.

Coronary heart disease

Coronary heart disease 冠心病 happens when the coronary arteries become narrow or blocked, so the heart muscle cannot get enough oxygen. **Risk factors** 风险因素 include a diet high in fat, lack of exercise, stress, smoking, family history (genetics), older age, and being male. A healthy diet and regular exercise lower the risk.



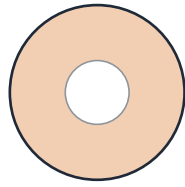
Coronary heart disease narrows the artery; several risk factors raise it and a healthy lifestyle lowers it

Blood vessels

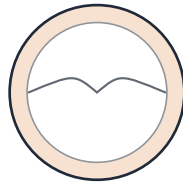
There are three kinds of blood vessel. The space inside a vessel is its **lumen** 管腔.

Vessel	Wall	Lumen	Valves?	Job
arteries 动脉	thick, muscular, elastic	narrow	no	carry blood away from the heart, at high pressure
veins 静脉	thin	wide	yes	carry blood back to the heart, at low pressure
capillaries 毛细血管	one cell thick	very narrow	no	let oxygen , glucose and wastes pass between blood and cells

(Supplement) Arteries have thick elastic walls to cope with the high pressure from the heart. Veins have valves because their blood is at low pressure and could otherwise flow backwards. Capillaries are very thin (one cell thick) and very narrow, giving a large **surface area** 表面积 and a short distance for fast exchange.



artery
thick muscular,
elastic wall;
narrow lumen;
high pressure



vein
thin wall;
wide lumen;
has **valves**;
low pressure



capillary
wall one cell
thick; lets
substances be
exchanged

Arteries, veins and capillaries are each built for their job

Main blood vessels

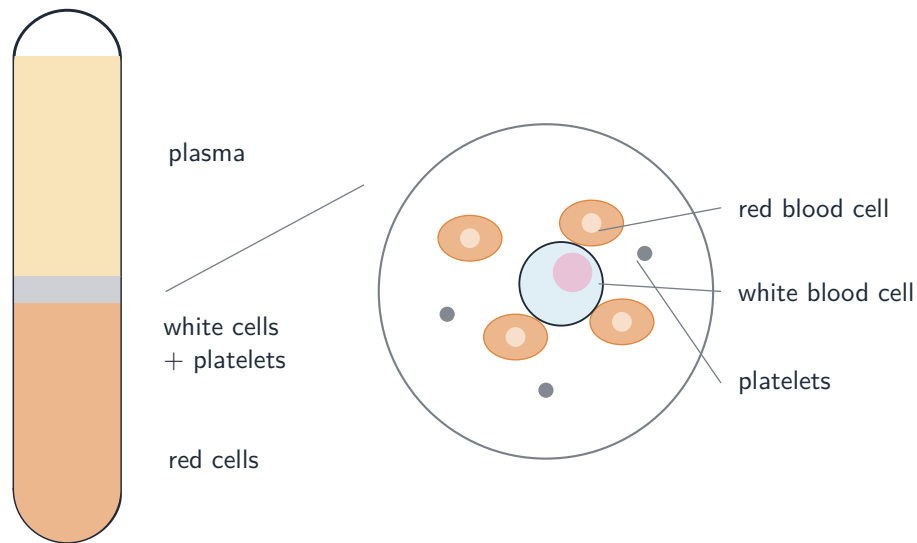
Connects	Artery (carries blood out)	Vein (carries blood in)
heart body	aorta 主动脉	vena cava 腔静脉
heart lungs	pulmonary artery 肺动脉	pulmonary vein 肺静脉
kidney	renal artery 肾动脉	renal vein 肾静脉

(Supplement) The liver is served by the **hepatic artery** 肝动脉, the **hepatic vein** 肝静脉, and the **hepatic portal vein** 肝门静脉, which brings blood from the gut to the liver.

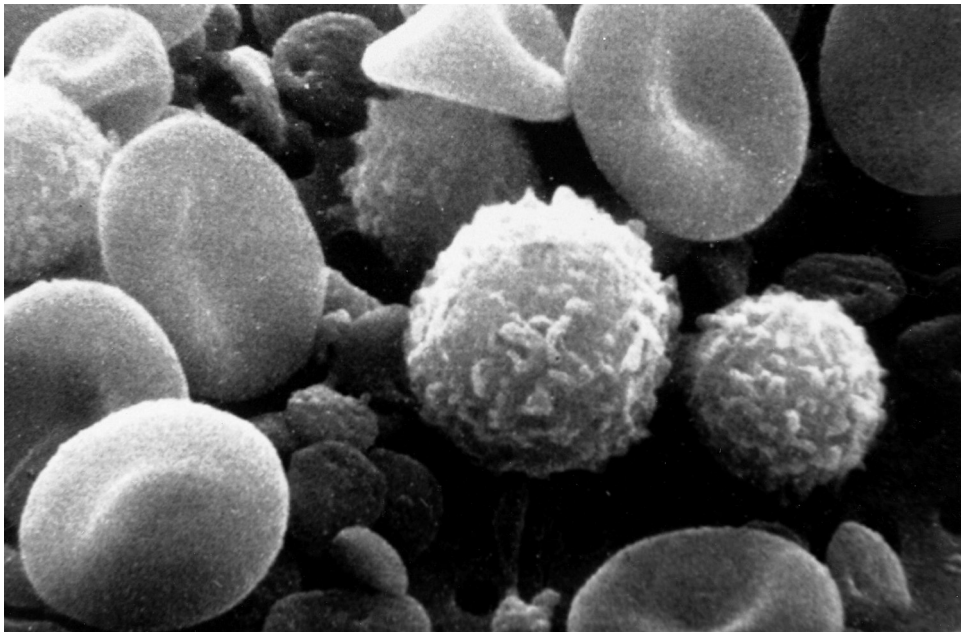
Blood

Blood has four parts:

Part	Function
red blood cells 红细胞	carry oxygen, using the red pigment 色素 haemoglobin 血红蛋白
white blood cells 白细胞	defend the body against disease
platelets 血小板	help the blood to clot 凝血
plasma 血浆	a liquid that carries blood cells, ions 离子, nutrients 营养物质, urea 尿素, hormones 激素 and carbon dioxide 二氧化碳



Blood is red cells, white cells and platelets carried in liquid plasma



Real blood cells under an electron microscope: red cells (discs), white cells and platelets

Image: Bruce Wetzel and Harry Schaefer (National Cancer Institute), Public domain (commons.wikimedia.org)

Defending the body, and clotting

White blood cells fight **pathogens** 病原体 (the microbes that cause disease) in two ways:

- **phagocytes** 吞噬细胞 carry out **phagocytosis** 吞噬作用—they surround and digest the pathogens.
- **lymphocytes** 淋巴细胞 make **antibodies** 抗体, which stick to the pathogens and destroy them.

When you cut yourself, the blood **clots** to seal the wound. This stops blood loss and stops pathogens getting in. **(Supplement)** During clotting, a soluble protein called

fibrinogen 纤维蛋白原 is changed into threads of **fibrin** 纤维蛋白. The threads form a net that traps blood cells and makes a solid clot.

Exam tips

- Circulatory system = pump (heart) + vessels + valves for one-way flow.
- Double circulation (mammals): blood passes through the heart twice. The left ventricle wall is thickest because it pumps to the whole body.
- Arteries carry blood **away** (thick, high pressure); veins carry it **back** (valves, low pressure); capillaries are for exchange (one cell thick).
- Blood = red cells (oxygen, haemoglobin) + white cells (defence) + platelets (clotting) + plasma (transport).
- Phagocytes engulf pathogens; lymphocytes make antibodies.