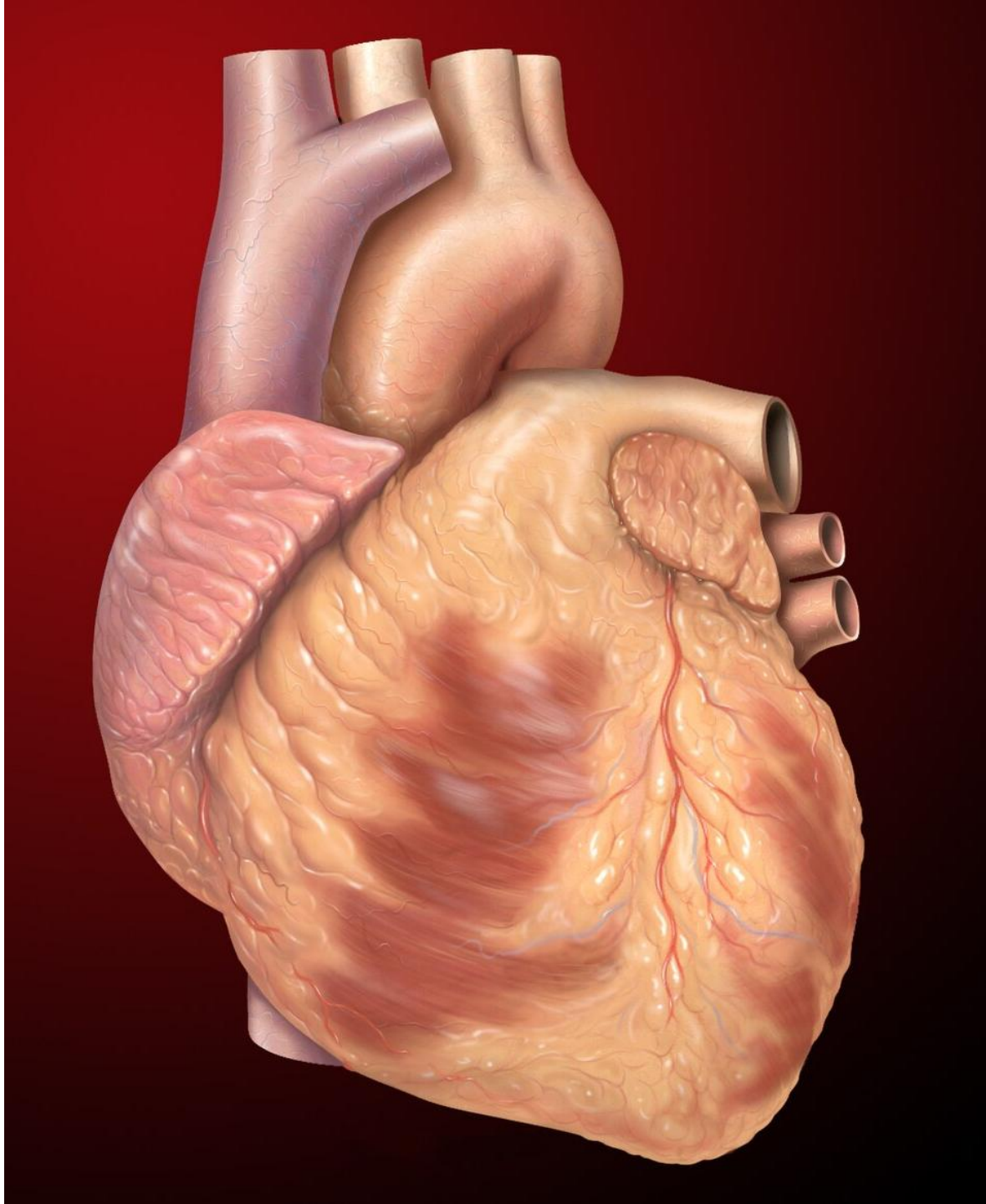
DP Biology – B3.2

Transport

- Which adaptations help animals and plants move fluids around?
- How does transport in animals compare with transport in plants?

Animal statements B3.2.1–6, SL and HL. Textbook pp. 295–302. Plants are in Plant Systems.
Image: human heart, anterior view. Patrick J. Lynch, CC BY 2.5.



Objectives for each class

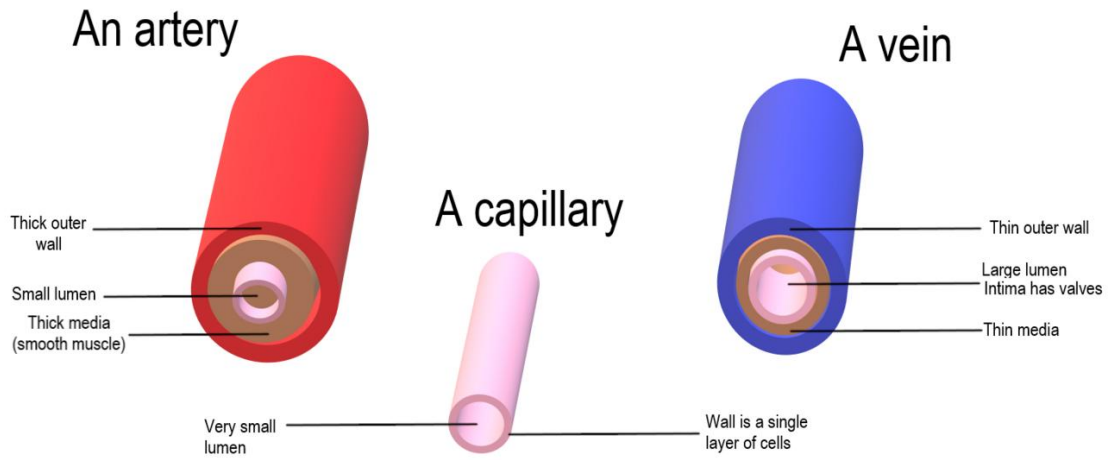
Class	Statements	By the end of the class, you can…
1	B3.2.1–2	Explain how capillaries suit exchange, and identify arteries and veins in micrographs
2	B3.2.3–5	Explain how arteries and veins are adapted to their pressures, and measure a pulse rate
3	B3.2.6	Explain the causes and consequences of coronary occlusion, and evaluate data on heart disease

Overview of this chapter

Part	Statements	What it covers
Capillaries	B3.2.1	How they exchange materials with tissues
Arteries and veins	B3.2.2	Telling them apart by the structure of the wall
Arteries	B3.2.3	Withstanding and maintaining high pressure
Pulse rate	B3.2.4	Taking a pulse, by hand and digitally
Veins	B3.2.5	Valves and flexible walls return the blood
Blocked arteries	B3.2.6	Causes, consequences and evaluating data

Three types of blood vessel

B3.2.1



Artery, capillary and vein compared. Christinelmiller, CC BY-SA 4.0.

	Role	Typical pressure	Flow
Arteries	Carry blood away from the heart	Up to 120 mm Hg	Fast, in pulses
Capillaries	Exchange with tissues	About 35 mm Hg	Slow, steady
Veins	Carry blood back to the heart	About 5 mm Hg	Steady

Capillaries are adapted for exchange

B3.2.1

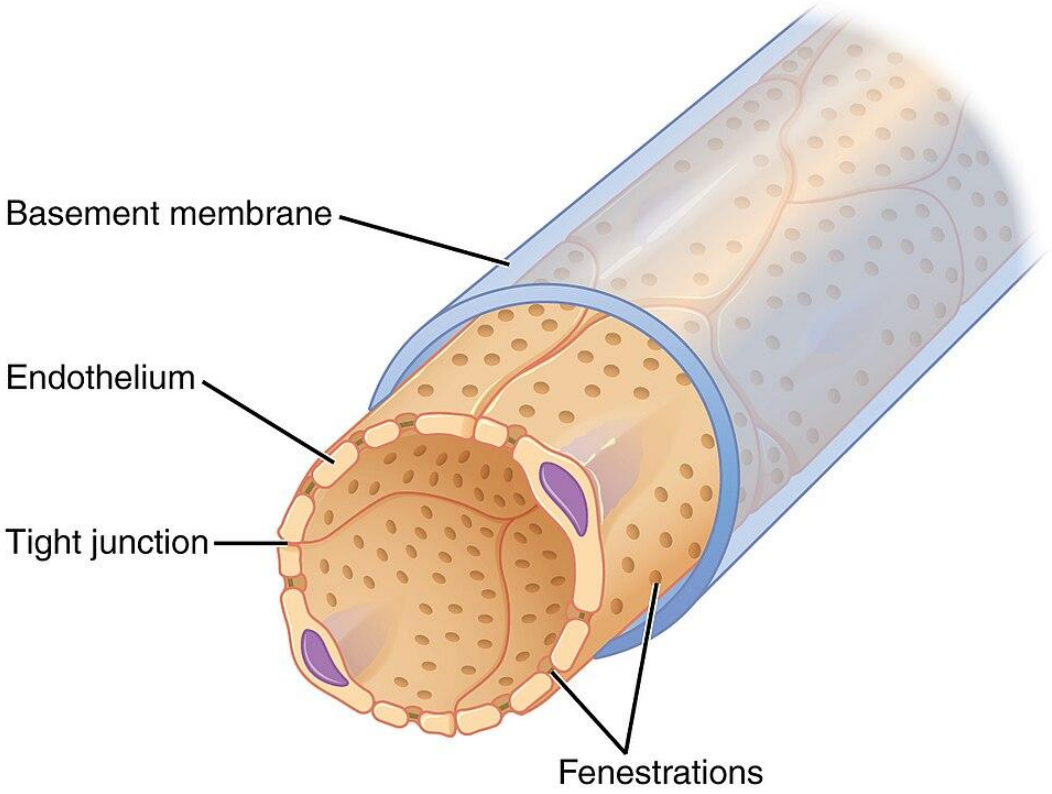
Feature	Why it helps exchange
Large surface area from branching	No cell is far from a capillary, and total area is huge
Narrow diameter, about 8 µm	Red blood cells pass close to the wall, reducing the distance
Thin wall: one layer of endothelial cells	The diffusion distance is short
Low pressure and slow flow	The wall does not burst, and there is more time for exchange

Key idea

Every feature of a capillary improves exchange between blood and tissue fluid. A capillary is the only type of vessel whose wall is thin enough for this to happen on a large scale.

Fenestrated capillaries: faster exchange

B3.2.1



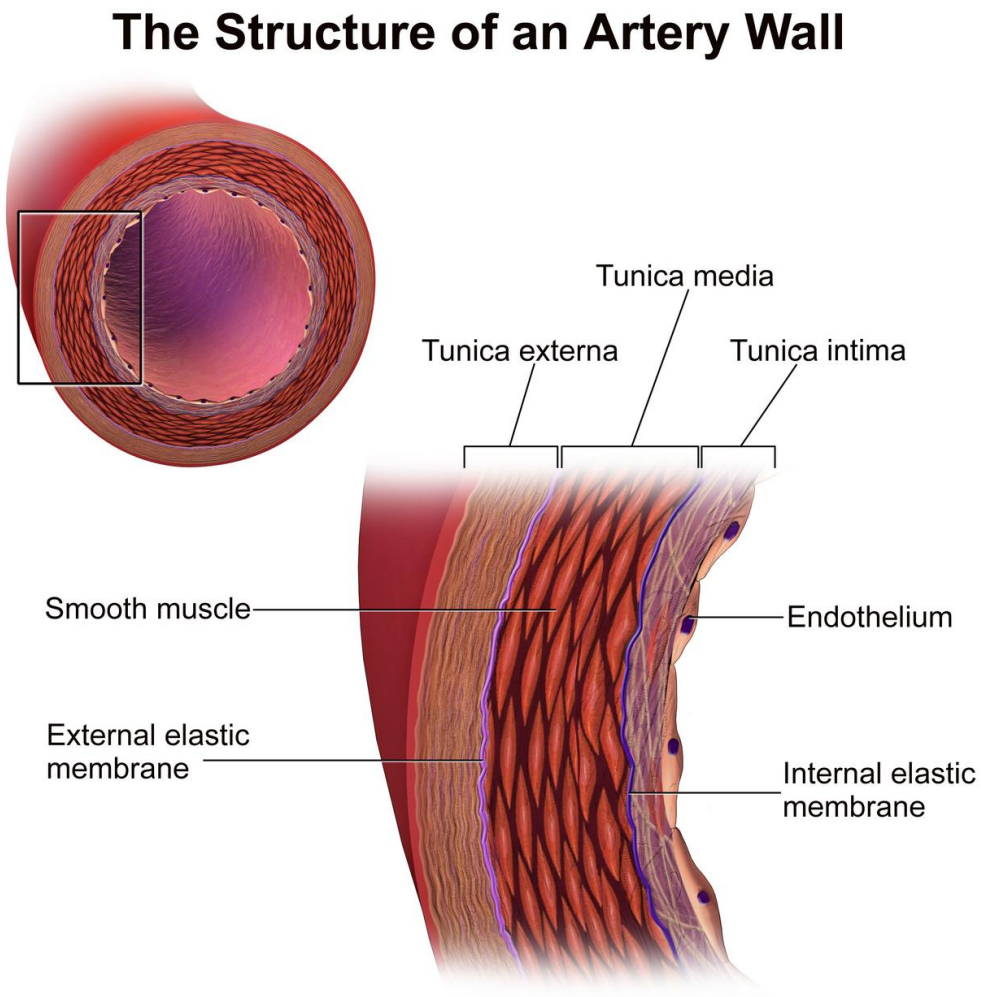
A fenestrated capillary, with pores through the endothelial cells. OpenStax College, CC BY 3.0.

- **Fenestrations** are small pores through the wall
- Found where exchange must be particularly rapid, such as the kidney and small intestine
- Plasma and small solutes leave more easily
- Cells and large proteins mostly stay in the blood
- The liquid that leaks out becomes **tissue fluid**

Question

Suggest why the capillaries in the villi of the small intestine are fenestrated.

The wall has three layers



- **Lumen**: the hollow centre
- **Tunica intima**: smooth endothelium, the inner lining, which reduces friction
- **Tunica media**: smooth muscle and elastic fibres, the middle layer
- **Tunica externa**: tough connective tissue with collagen, the outer layer

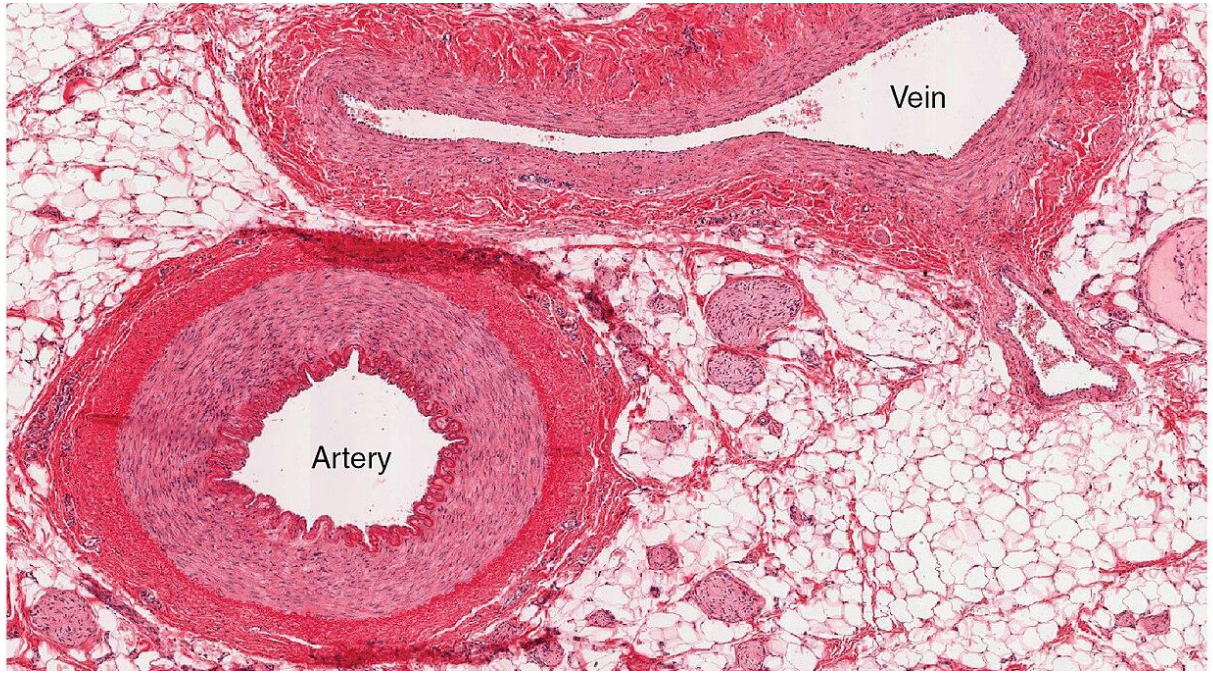
Key idea

Arteries and veins have the same three layers. What differs is how thick they are, and that depends on the pressure inside.

Artery wall. BruceBlaus, CC BY 3.0.

Identifying vessels in a micrograph

B3.2.2



Light micrograph: artery (below) and vein (above), in the same section. OpenStax College, CC BY 3.0.

- Compare the **wall thickness** with the **lumen diameter**
- Artery: thick wall, narrow lumen
- Vein: thin wall, wide lumen
- Arteries tend to look round
- Veins often look squashed or irregular

Common mistake

Do not judge by overall size. Use the wall relative to the lumen.

Arteries and veins compared

B3.2.2

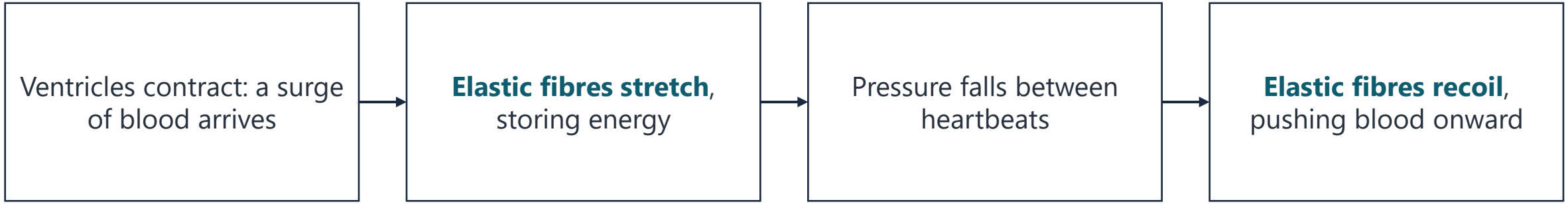
	Artery	Vein
Wall relative to lumen	Thick	Thin
Lumen	Narrow	Wide
Tunica media	Thick: much muscle and elastic tissue	Thin: little muscle and elastic tissue
Valves	None, except at the heart	Present, especially in the limbs
Pressure	High, in pulses	Low, no pulse

Activity

Without looking, sketch both vessels in cross-section and label all three layers.

Elastic walls even out the pressure

B3.2.3



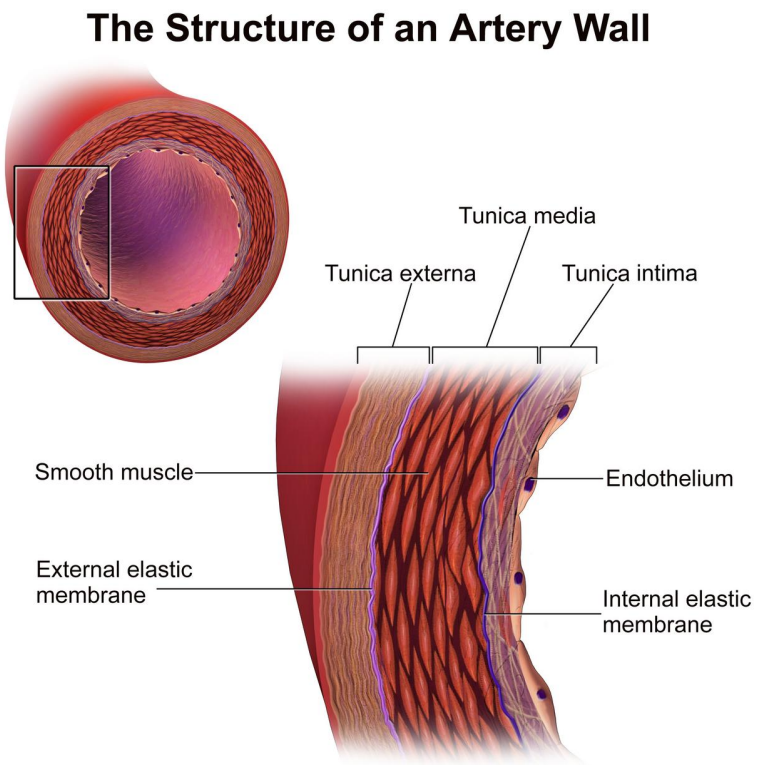
- Blood pressure in the aorta reaches about 120 mm Hg
- Recoil keeps blood flowing and maintains pressure between pulses
- Further from the heart, the tunica media has more muscle and less elastic tissue

Key idea

Two words to use: arteries must withstand high pressure, which is about strength, and maintain high pressure, which is about elasticity and muscle.

What each tissue does

B3.2.3



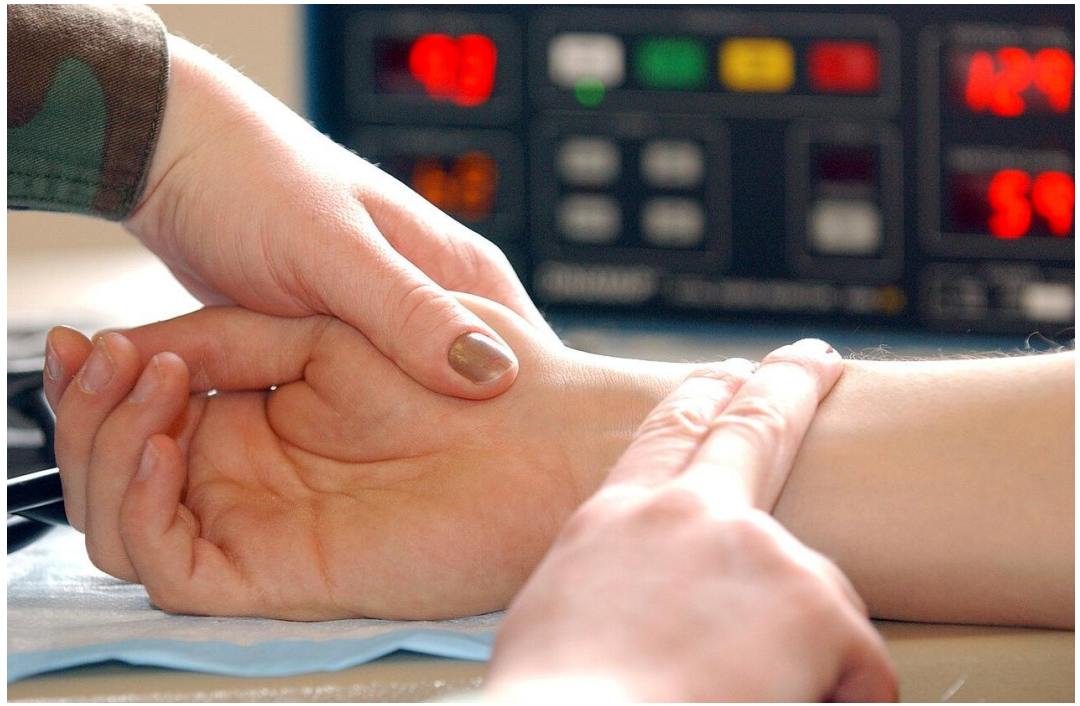
Tissue	Role in an artery
Elastic fibres	Stretch and recoil, maintaining pressure
Smooth muscle	Contracts to narrow the lumen and helps maintain pressure
Collagen	Strong: prevents rupture as blood surges
Thick wall overall	Withstands high pressure

Layers of an artery wall. BruceBlaus, CC BY 3.0.

Link

Arteries lead to arterioles, which have a high proportion of smooth muscle. They regulate how much blood reaches each capillary bed.

Taking a pulse



Feeling the radial pulse with two fingertips. Jeanette Copeland, US Air Force, public domain.

- Each ventricular contraction sends a wave through the arteries
- Feel it where an artery is near the skin and over bone
- **Radial artery**: above the wrist, on the thumb side
- **Carotid artery**: at the side of the neck, below the jaw
- Count for a full minute, or 30 seconds and double it

Common mistake

Use your fingertips, not your thumb. Your thumb has a pulse of its own, which you could count by mistake.

Traditional and digital methods

B3.2.4

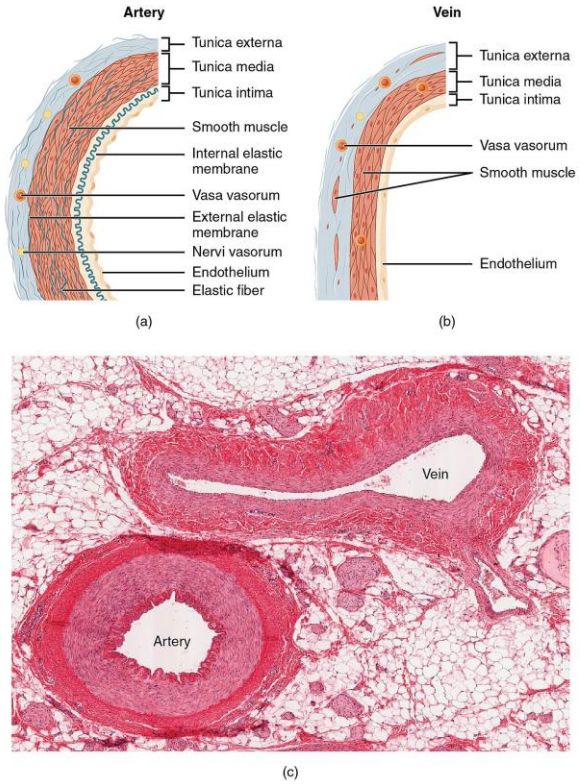
	Fingertips and a timer	Watch, oximeter or data logger
How	Feel and count the pulses	An LED shines through skin; a sensor measures changes in blood flow
Advantage	Free, simple, can be done anywhere	Continuous, can record during exercise
Limitation	Counting errors; hard while moving	Cost; accuracy varies with device and fit

Activity

Measure a resting pulse by both methods, three times each. Then measure recovery after two minutes of gentle exercise. Which method gives more consistent readings? Volunteers only; anyone with a heart or breathing condition acts as timer.

Veins return blood at low pressure

- Blood has lost its pressure in the capillaries, so there is no pulse
- Pressure falls to about 5 mm Hg
- **Wide lumen** reduces friction, so blood flows freely
- **Thin, flexible wall** can be compressed by surrounding muscles
- **Valves** stop blood flowing backwards

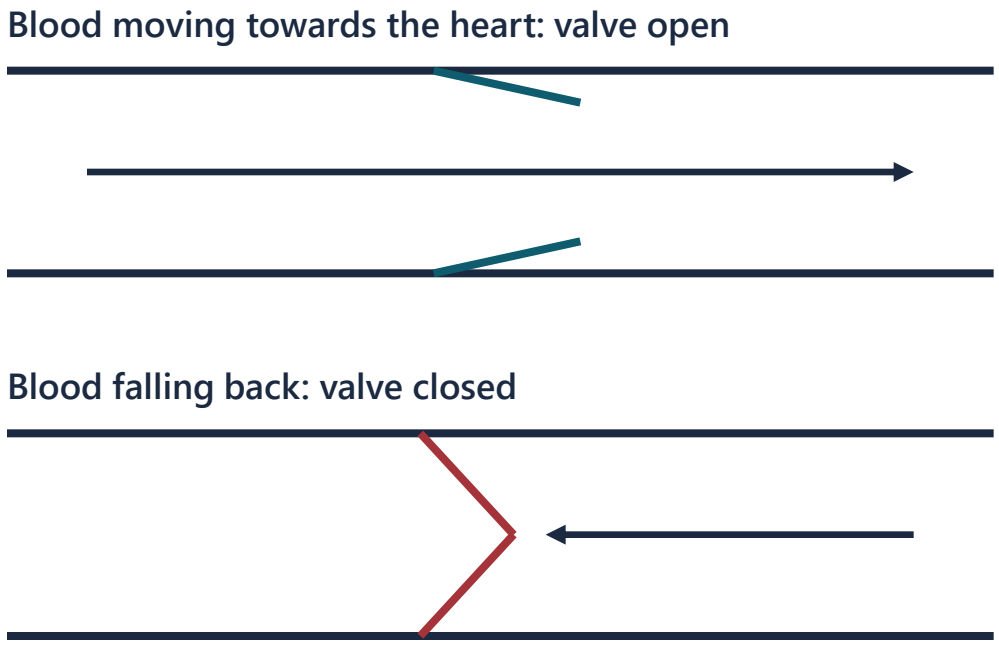


Structure of artery and vein walls, with a micrograph. OpenStax College, CC BY 3.0.

Question

Why would a thick, rigid wall be a disadvantage for a vein, when it is an advantage for an artery?

Valves and muscle action



Schematic of a vein in section, with the heart to the right.

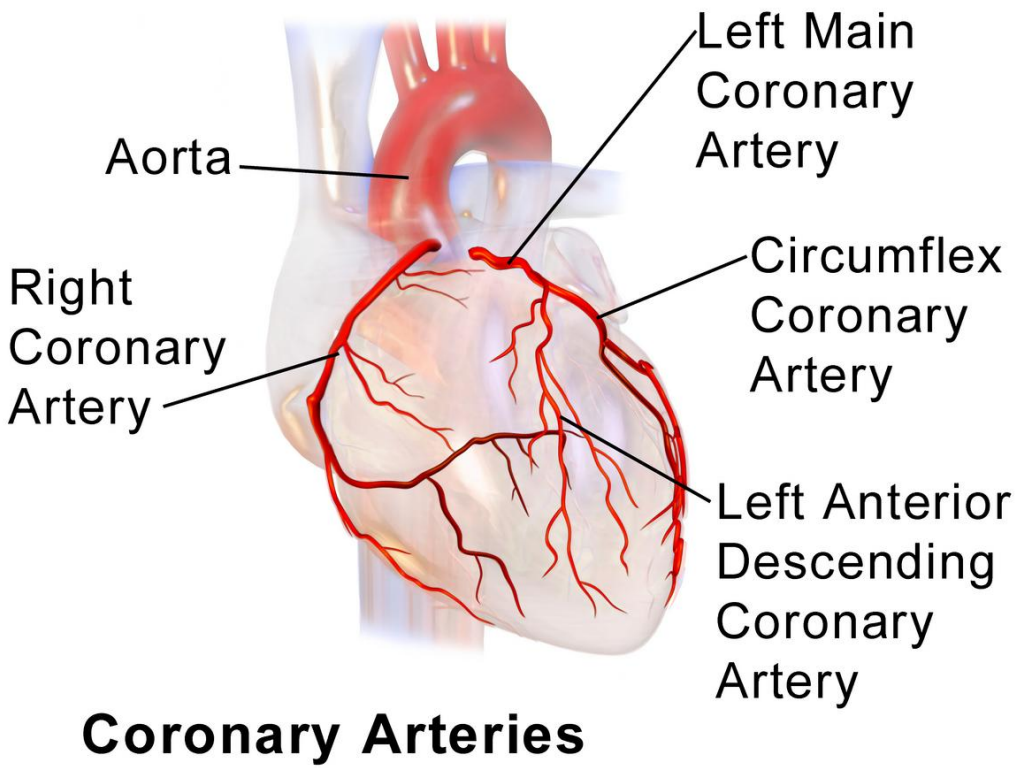
1. Skeletal muscles contract and squeeze nearby veins
2. Blood is pushed along the vein
3. Blood moving towards the heart pushes the valve flaps open
4. Blood falling back fills the pockets and closes the flaps
5. So blood can only move in one direction

Link

This is why walking or even fidgeting helps blood return from the legs, and why standing still for hours can make feet swell or lead to fainting.

Coronary arteries supply the heart

B3.2.6



The coronary arteries. BruceBlaus, CC BY 3.0.

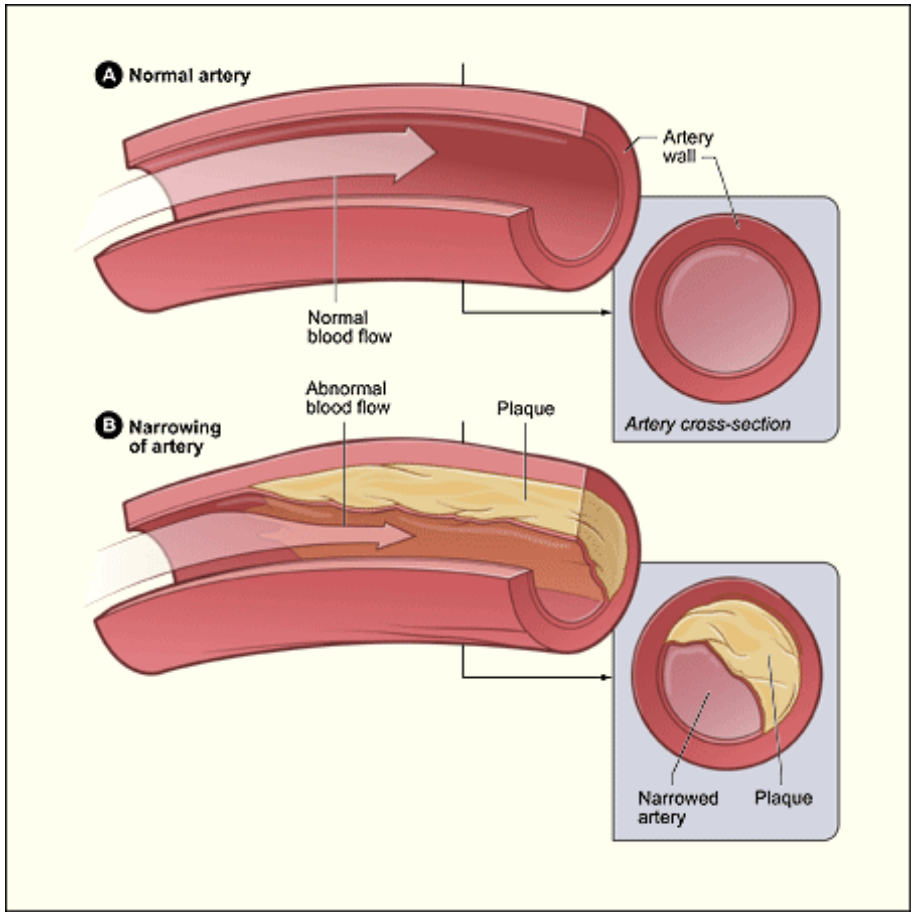
- Heart muscle needs a constant supply of oxygen and glucose
- The blood inside the chambers does not supply it
- **Coronary arteries** branch from the aorta and spread over the heart
- **Occlusion** is a blockage or closing of a blood vessel
- Branches supplying the left ventricle are especially at risk

Key idea

A block starves only the muscle downstream of it, but that can stop the heart pumping effectively.

How arteries become blocked

B3.2.6



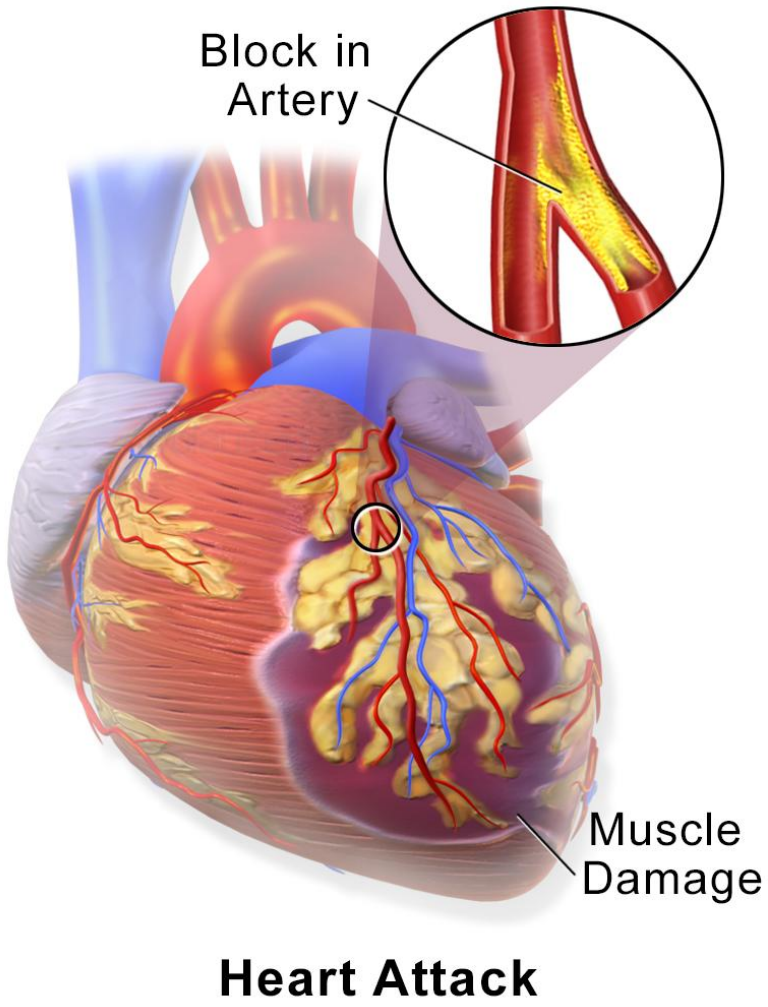
Normal artery (A) and artery narrowed by plaque (B). NHLBI, public domain.

1. Fatty deposits called **atheroma** form under the endothelium
2. The lumen narrows, reducing blood flow
3. Blood pressure rises and damages the wall further
4. Fibrous repair tissue makes the wall less elastic
5. The smooth lining breaks down, forming a **plaque**
6. A ruptured plaque triggers clotting: a **thrombus**
7. A clot that breaks free and circulates is an **embolus**

Common mistake

Plaque forms within the wall, beneath the endothelium, and not on top of it.

Consequences of occlusion



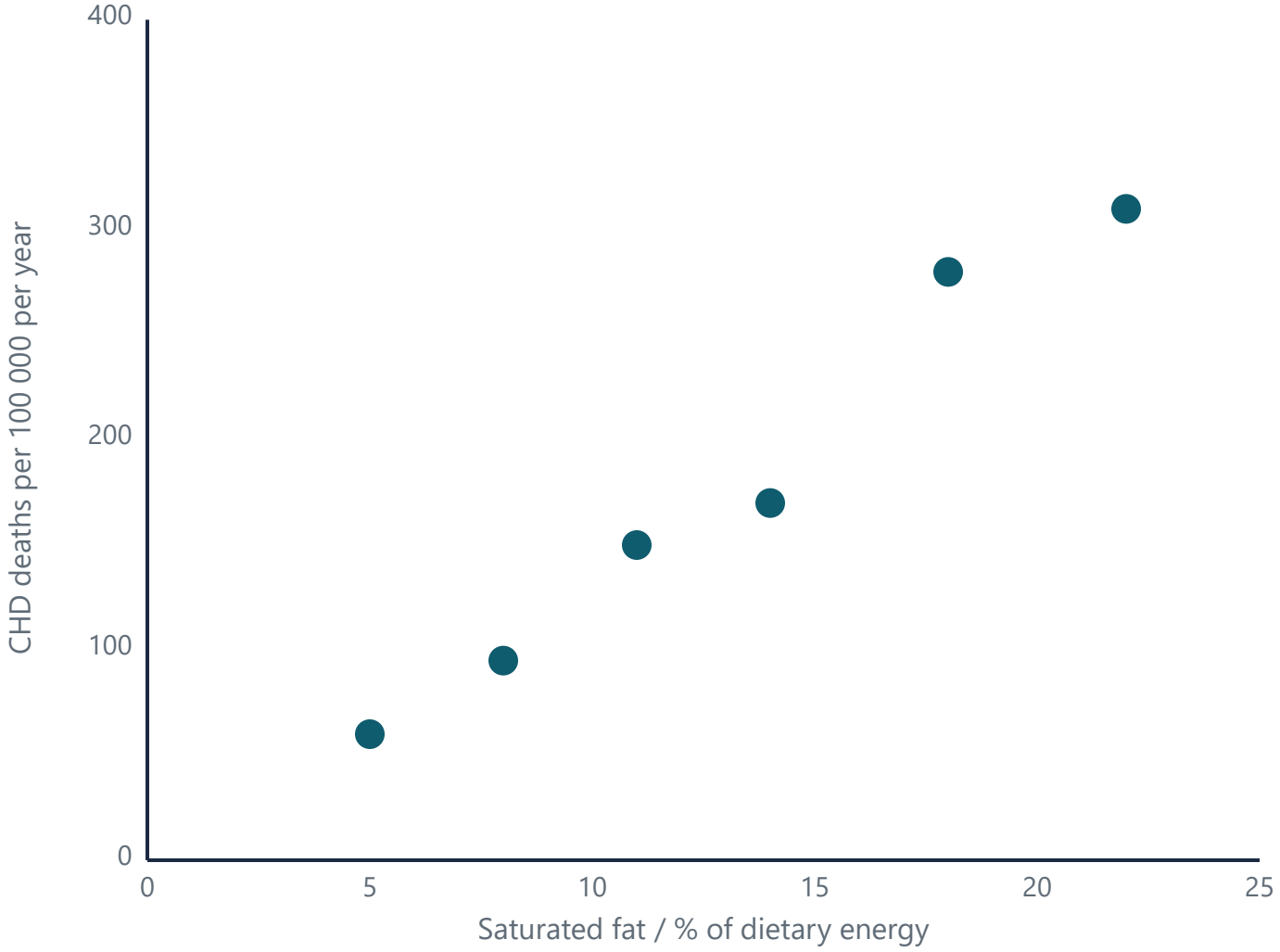
Blocked coronary artery and damaged muscle. Blausen Medical, CC BY 3.0.

Degree of block	What follows
Partial narrowing	Less oxygen in exercise; chest pain (**angina**) and short breath
Complete block	Muscle downstream cannot respire aerobically, and dies
Enough muscle lost	Heart cannot pump effectively: a **heart attack** or myocardial infarction

Risk factors

High blood pressure, smoking, a diet high in saturated fat, obesity, diabetes, lack of exercise, age and family history. A blocked artery can be bypassed using a vessel from the leg.

Evidence from populations



Invented data for six fictional countries, for practice only.

- **Epidemiological studies** compare populations and show correlations
- **Clinical studies** follow individual patients
- Controlled trials on diet are often impossible, for ethical and practical reasons

Key idea

A strong correlation suggests a link, but it does not prove that one factor causes the other.

Evaluating data on heart disease

B3.2.6

Strengths to look for	Limitations to look for
Statistically significant correlation	Small sample, or not representative of the population
Large sample over a long period	Other variables not controlled, such as smoking
Little spread in the data; small error bars	Survey data that depend on honest reporting
Valid measure of health	Results from animals may not apply to humans

Activity

Find a data set on coronary heart disease rates in different countries. In a paragraph, state the correlation, give two possible confounding variables, and say what further evidence would support a causal link.

Check that you can explain

1. Four features that help capillaries exchange
2. What fenestrations are for
3. The three layers of a vessel wall
4. How to identify vessels in a micrograph
5. How arteries withstand and maintain pressure
6. How to take a pulse accurately
7. How veins and valves return blood
8. What causes occlusion of coronary arteries
9. Why occlusion can cause a heart attack
10. Why correlation does not prove causation

Exit activity: 5 minutes

On your own and without notes. Hand this in as you leave.

1. Give one adaptation of a capillary and explain how it helps exchange.

2. Vessel X has a wall 1.2 mm thick and a lumen 4 mm wide. Vessel Y has a wall 0.4 mm thick and a lumen 5 mm wide. Which is the artery, and how can you tell?

3. In two sentences, explain how a plaque can lead to a heart attack.

Image credits

Heart anterior exterior view.jpg – Patrick J. Lynch – CC BY 2.5
Artery Vein Capillary Comparison.png – Christinelmiller – CC BY-SA 4.0
2614 Fenestrated Capillary.jpg – OpenStax College – CC BY 3.0
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