

Cardiovascular disease and its causes

Revision notes · How atherosclerosis and blood clots lead to cardiovascular disease, the risk factors, dietary antioxidants, and Core practical 2 on vitamin C.

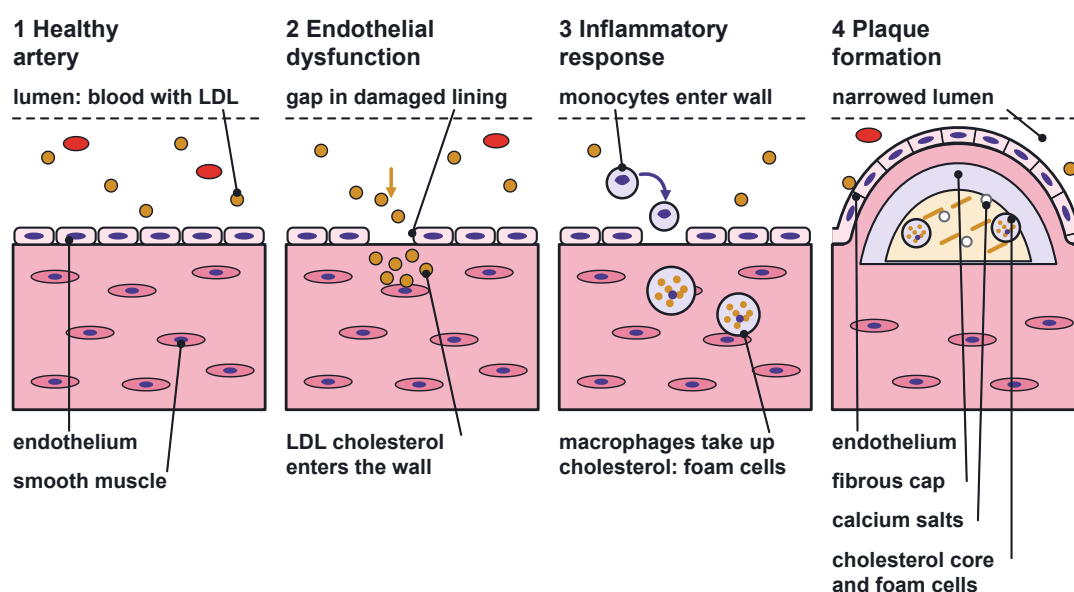
For Pearson Edexcel International AS Biology XBI11 and International A Level Biology YBI11. **A Level only** is IA2 content (Units 4 to 6), not needed for the International AS.

Cardiovascular disease and its causes Spec 1.10-1.14

Atherosclerosis Spec 1.10

Cardiovascular disease (CVD) is the name for diseases of the heart and blood vessels, including coronary heart disease, strokes and high blood pressure. The most common underlying process is **atherosclerosis**.

1. **Endothelial dysfunction**: the endothelium (inner lining of the artery) is damaged, for example by high blood pressure, chemicals in tobacco smoke or high blood glucose. The damaged lining becomes more permeable, and LDL cholesterol from the blood enters the artery wall.
2. **Inflammatory response**: the damaged tissue attracts white blood cells (monocytes). They enter the wall, become macrophages and take up the cholesterol, forming foam cells. They release chemicals that attract more white blood cells.
3. **Plaque formation**: foam cells, cholesterol, dead cells, and smooth muscle cells that have moved into the area build up as an **atheroma** (plaque). Fibres and calcium salts are deposited, forming a hardened cap over the plaque.
4. The plaque makes the lumen narrower and the artery wall less elastic. Blood flow is reduced and **blood pressure rises**.
5. Raised blood pressure damages the endothelium further, so the process speeds up (a positive feedback).



Atherosclerosis: **endothelial dysfunction**, inflammatory response, then a plaque (atheroma) forms inside the artery wall and narrows the lumen.

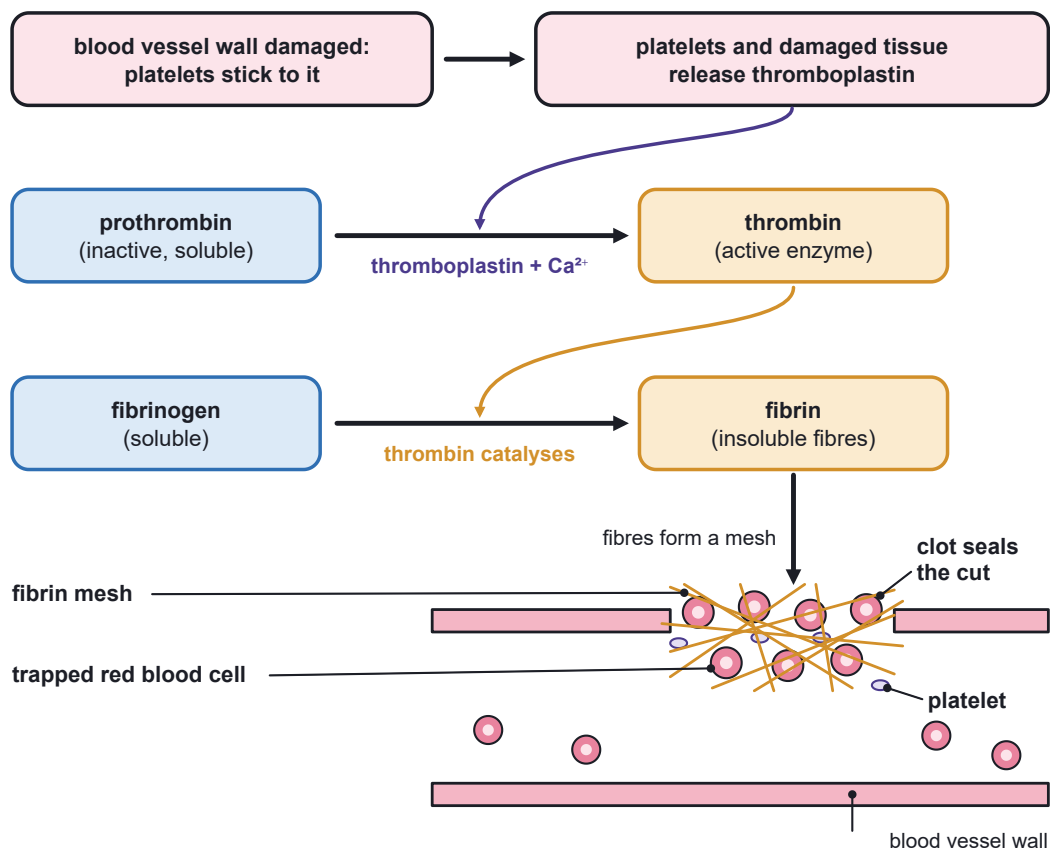
Reduced blood flow means less oxygen reaches the tissue supplied by the artery. In a coronary artery this can cause chest pain (angina). A plaque can also rupture, exposing the artery wall to the blood and triggering blood clotting (see the next section).

Exam tip: Learn the four named stages in order: endothelial dysfunction, inflammatory response, plaque formation, raised blood pressure. Say that raised blood pressure both results from and causes more damage.

Blood clotting and cardiovascular disease Spec 1.11

When a blood vessel is damaged, platelets stick to the damaged surface and release chemicals. Platelets and the damaged tissue release **thromboplastin** (a clotting factor). This starts a cascade of reactions.

1. Thromboplastin (with calcium ions) catalyses the conversion of the inactive plasma protein **prothrombin** to the enzyme **thrombin**.
2. Thrombin catalyses the conversion of soluble **fibrinogen** to insoluble **fibrin**.
3. Fibrin forms long fibres that make a mesh. The mesh traps red blood cells and platelets, forming a **clot** that seals the damage and stops blood loss.



The clotting cascade: **prothrombin → thrombin**, then fibrinogen → fibrin, which forms the clot.

Role in cardiovascular disease

- A plaque can rupture and expose the artery wall. Clotting is triggered and a **thrombus** forms on the plaque, blocking a narrowed artery.
- If the blocked artery is a **coronary artery**, the cardiac muscle supplied is starved of oxygen and glucose, cannot respire aerobically and dies. This is a **myocardial infarction** (heart attack).
- If the blocked artery supplies the brain, the result is a **stroke**.
- A clot can also break away and travel in the blood (an embolus) until it lodges in a narrower vessel.

Common mistake: Fibrinogen is soluble and fibrin is insoluble, and thrombin is an enzyme made from inactive prothrombin. Do not swap these pairs, and keep the order: thromboplastin, prothrombin to thrombin, fibrinogen to fibrin.

Risk factors for cardiovascular disease Spec 1.12

A **risk factor** is something that is linked to an increased probability of developing a disease. It does not mean that a person will definitely get the disease, and a person with no risk factors can still develop it.

How risk factors increase the risk of CVD	
Risk factor	How it increases risk
Genetics	Inherited gene variants can affect blood cholesterol (for example high LDL), blood pressure and clotting, so a family history of CVD raises risk
Diet	High saturated fat raises LDL cholesterol; high salt raises blood pressure; both promote atherosclerosis
Age	Risk rises with age: endothelial damage and plaque build up over many years, and arteries lose elasticity
Gender	Men are at higher risk, and at a younger age, than women; the risk for women rises after the menopause
High blood pressure	Damages the endothelium, so LDL enters the wall and plaques form faster; it also strains the heart
Smoking	Carbon monoxide binds to haemoglobin and reduces oxygen transport; nicotine raises heart rate and blood pressure; chemicals damage the endothelium; platelets become stickier, so clots form more easily
Inactivity	Associated with raised blood pressure, higher LDL and lower HDL, and with obesity

Risk factors combine. A smoker who also has high blood pressure and a diet high in saturated fat has a much greater risk than the effect of any one factor alone, because each adds to the damage to the artery wall.

Exam tip: Write 'increases the risk of' rather than 'causes', and give the mechanism: damage to endothelium, raised LDL, raised blood pressure or more likely clotting.

Dietary antioxidants and the risk of CVD Spec 1.13

Free radicals are very reactive molecules, formed in normal metabolism and by factors such as tobacco smoke. They damage cell membranes and other molecules. In artery walls they damage endothelial cells and **oxidise LDL cholesterol**. Macrophages take up oxidised LDL more readily, forming foam cells, so oxidation speeds up the formation of atheroma.

Antioxidants are substances that neutralise free radicals, by donating electrons to them. Dietary antioxidants include vitamin C, vitamin E and carotenoids. They are found in fruit, vegetables, nuts and seeds. A higher intake of antioxidants is expected to reduce LDL oxidation and endothelial damage, and so reduce the risk of CVD.

The evidence

- Studies of populations show that people who eat more fruit and vegetables have a lower incidence of CVD.
- But this may be due to other differences (such as less saturated fat, more fibre or more exercise), so it does not show that antioxidants are the cause.

- Trials giving people antioxidant supplements have mostly found little or no benefit. A diet of whole foods may work through the combination of nutrients, not a single antioxidant.

Exam tip: A good answer to 'discuss the link' states the mechanism (neutralise free radicals, less oxidised LDL, less foam cell formation) and then comments on the conflicting evidence.

Core practical 2: vitamin C content of food and drink Spec 1.14

Core practical: Core practical 2: investigate the vitamin C content of food and drink.

DCPIP (dichlorophenolindophenol) is a blue dye. Vitamin C (ascorbic acid) is a reducing agent: it reduces DCPIP to a colourless compound. The more vitamin C a solution contains, the less of it is needed to decolourise the same volume of DCPIP.

1. Make standard solutions of ascorbic acid of known concentration (for example 1.0 mg cm^{-3} and dilutions of it).
2. Place a fixed volume of DCPIP solution (for example 1 cm^3) in a test tube or small beaker.
3. Add the first standard drop by drop from a graduated pipette or burette, shaking the tube after each drop, until the blue colour just disappears. Record the volume added.
4. Repeat with each standard and plot a calibration curve of volume needed against concentration (or use the standard which decolourises 1 cm^3 DCPIP to find its equivalent).
5. Extract juice from a solid food by crushing it in water and filtering, then treat the unknown in exactly the same way. Repeat each measurement at least three times and calculate a mean.
6. Use the volume needed and the calibration to find the vitamin C concentration of the unknown.

Variables in the DCPIP method	
Type	Variable
Independent	Type of food or drink, or its treatment (for example fresh or boiled)
Dependent	Volume of sample needed to decolourise DCPIP, which gives the vitamin C concentration
Controlled	Volume and concentration of DCPIP, temperature, rate of adding drops, same measuring equipment, fresh solutions each time, time between preparing and testing

Risks: DCPIP can stain and irritate skin and eyes, so wear eye protection and gloves and wipe spillages. Do not eat or drink any food used in the laboratory.

Limitations: vitamin C is destroyed by heat, light and air (oxidation), so keep solutions cool and fresh and test promptly. Other reducing substances in a food may also decolourise DCPIP. The end point is judged by eye, which is more difficult in coloured juices, so dilute the juice or use a paler food, and use the same observer.

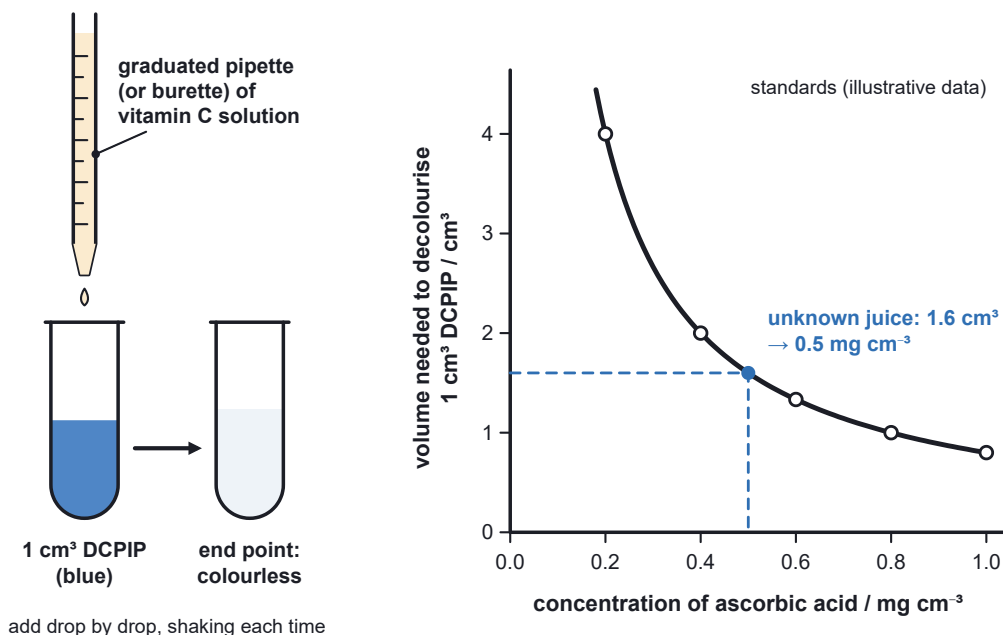
Calculating vitamin C concentration

It takes 0.8 cm^3 of a 1.0 mg cm^{-3} ascorbic acid standard to decolourise 1 cm^3 of DCPIP. It takes 1.6 cm^3 of fruit juice to decolourise 1 cm^3 of the same DCPIP. Calculate the vitamin C concentration of the juice, and the percentage change if boiling the juice raises the volume needed to 2.0 cm^3 .

1. Mass of vitamin C that decolourises 1 cm^3 DCPIP = $0.8 \text{ cm}^3 \times 1.0 \text{ mg cm}^{-3} = 0.8 \text{ mg}$
2. Concentration of juice = $0.8 \text{ mg} \div 1.6 \text{ cm}^3 = 0.5 \text{ mg cm}^{-3}$
3. Boiled juice = $0.8 \text{ mg} \div 2.0 \text{ cm}^3 = 0.4 \text{ mg cm}^{-3}$
4. Percentage change = $(0.4 - 0.5) \div 0.5 \times 100 = -20 \%$

Answer: 0.5 mg cm^{-3} ; boiling reduced the concentration by 20 %.

Maths skill: Percentage change = (new value – original value) ÷ original value × 100. A negative answer is a decrease. Show the working and include units for concentrations.



Core practical 2: the **less juice needed** to decolourise DCPIP, the more vitamin C it contains.

Quick check

1. Name the four stages in the course of events leading to atherosclerosis.
2. What does thrombin do?
3. Give two ways smoking raises the risk of CVD.
4. How do antioxidants reduce the risk of CVD?
5. In Core practical 2, what colour change shows vitamin C?

Quick check answers

Cardiovascular disease and its causes

1. Endothelial dysfunction, inflammatory response, plaque formation and raised blood pressure.
2. It is an enzyme that catalyses the conversion of soluble fibrinogen to insoluble fibrin.
3. Any two of: carbon monoxide reduces oxygen carried by haemoglobin; nicotine raises heart rate and blood pressure; chemicals damage the endothelium; platelets are stickier.
4. They neutralise free radicals, so less LDL is oxidised and there is less endothelial damage and foam cell formation.
5. Blue DCPIP turns colourless.