SL IB Biology

Your notes

Transport

Contents

Blood Vessels

Your notes

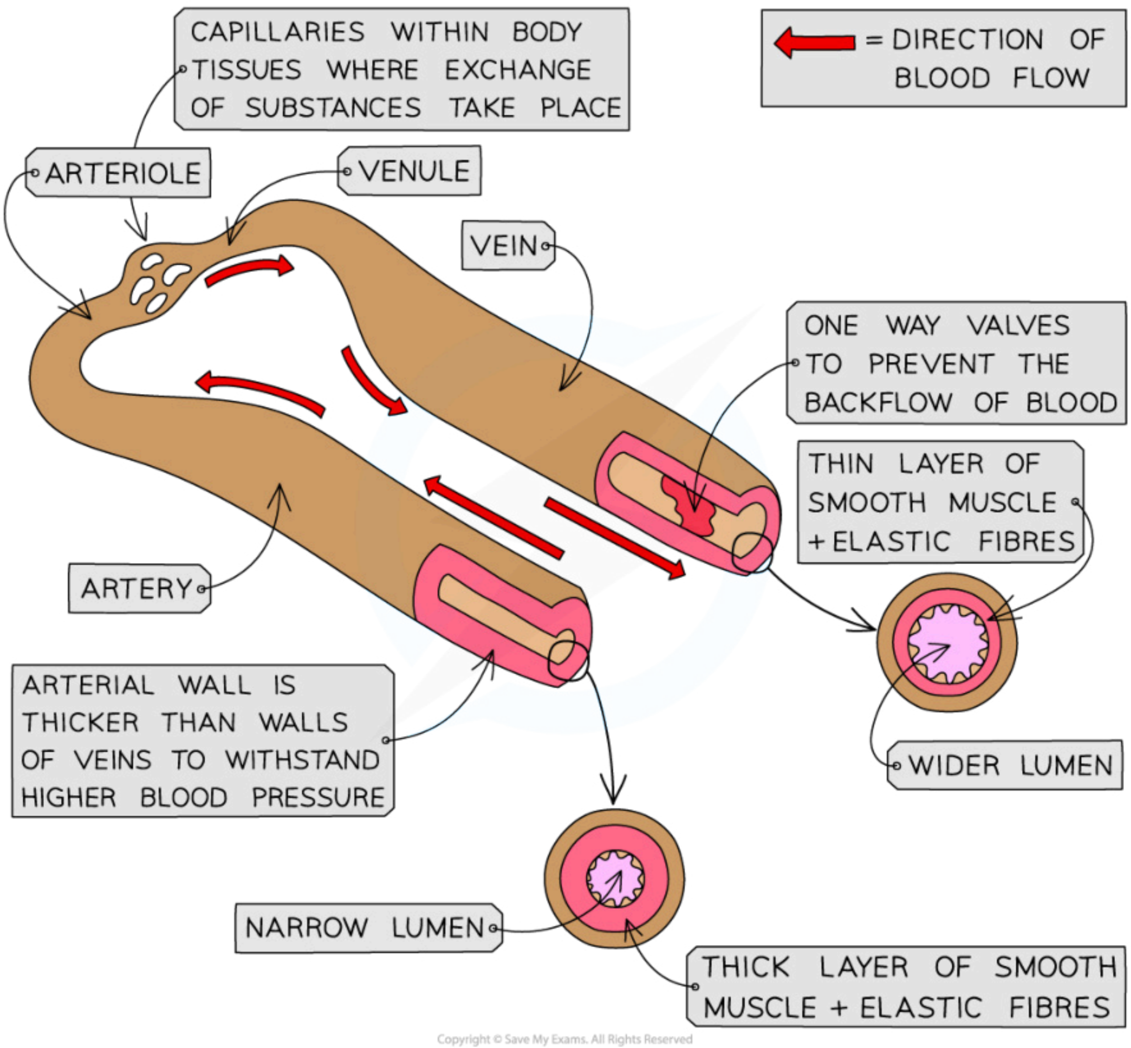
Capillaries

Introduction to blood vessels

- The **circulatory system** of the human body contains several different types of **blood vessel**:
  - Arteries
  - Arterioles
  - Capillaries
  - Venules
  - Veins
- Each type of blood vessel has a **specialised structure** that relates to the function of that vessel

Blood vessels diagram

Your notes



The circulatory system includes several blood vessels, each specialised to carry out its function

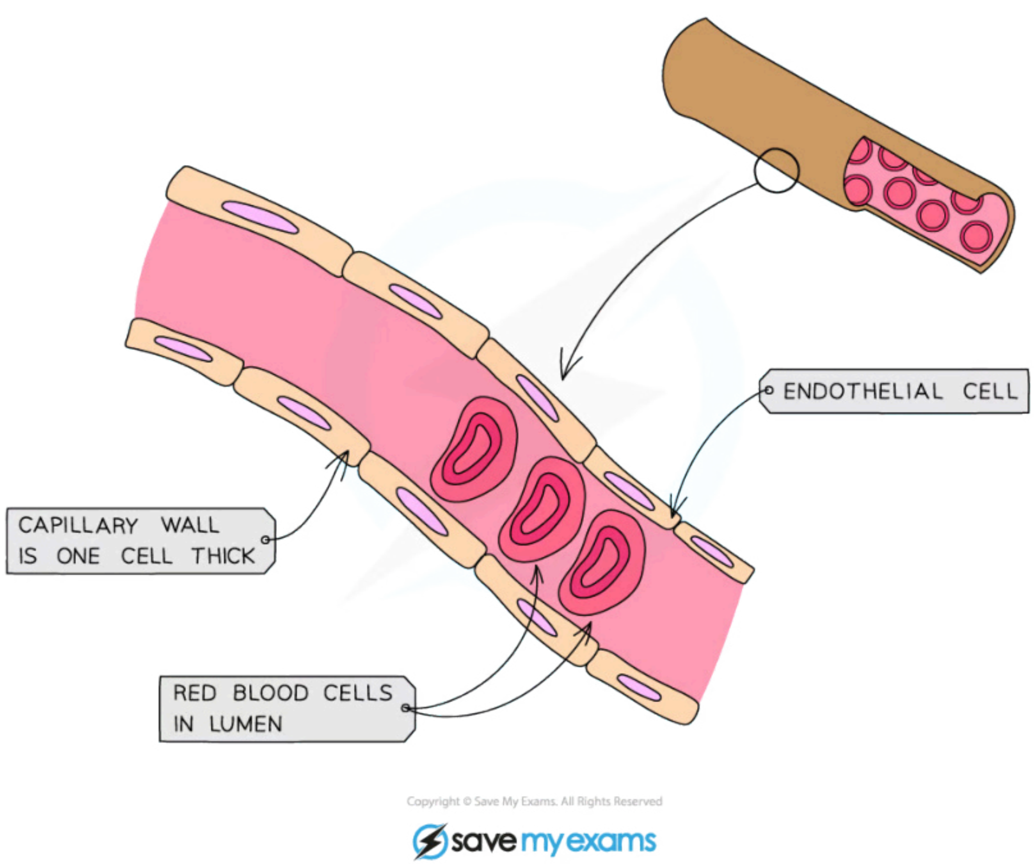
Adaptations of capillaries for exchange of materials

- **Capillaries** provide the **exchange surface** in the tissues of the body through a network of vessels called capillary beds
  - The wall of a capillary is made from a **single layer** of **endothelial cells**
    - Being just **one cell thick** reduces the **diffusion distance** for oxygen and carbon dioxide between the blood and the tissues of the body
  - The thin endothelium cells of some capillaries have gaps between them called **fenestrations** which allow blood plasma to leak out and form **tissue fluid**
    - Tissue fluid surrounds the cells, enabling **exchange** of substances such as oxygen, glucose, and carbon dioxide
    - Tissue fluid contains **oxygen, glucose** and other small molecules from the blood plasma

- Large molecules such as proteins usually can't fit through the fenestrations into the tissue fluid
- The **permeability** of capillaries can vary depending on the requirements of a tissue
- Capillaries form branches in between the cells; this is the capillary bed
    - These branches increase the **surface area** for diffusion of substances to and from the cells
    - Being so close to the cells also reduces the **diffusion distance**
- Capillaries have a lumen with a **small diameter**
    - Red blood cells squeeze through capillaries in single-file
    - This forces the blood to travel slowly which provides more opportunity for diffusion to occur
    - It also **reduces** the diffusion distance as red blood cells are brought in close contact with the capillary wall

Your notes

Capillary structure diagram



Capillaries have a narrow lumen and walls that are one cell thick to increase the rate of diffusion between the blood and cells

Arteries

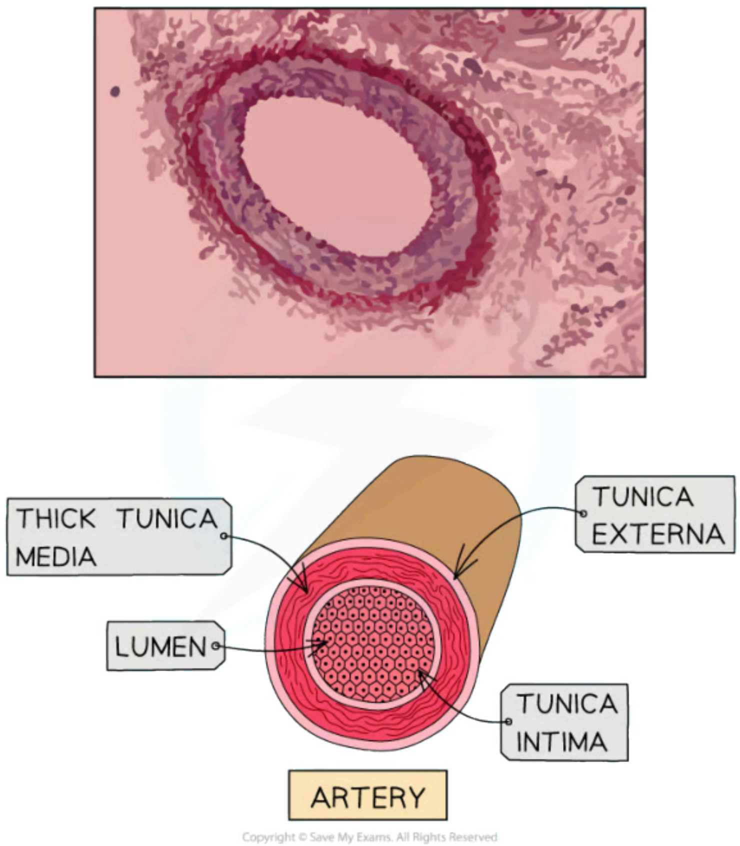
Adaptations of arteries

- **Arteries** transport blood away from the heart at **high pressure**
  - Blood travels from the ventricles to the tissues of the body
  - Remember; **a**rteries carry blood **a**way from the heart
- Artery walls consist of **three layers**:
  - The innermost layer is an endothelial layer, consisting of squamous epithelium
    - The endothelium is one cell thick and lines the lumen of all blood vessels. It is **very smooth and reduces friction** for free blood flow
  - The middle layer contains **smooth muscle cells** and a **thick layer of elastic tissue**
    - This layer is very **thick** in the walls of arteries
    - The layer of **muscle**:
      - **Strengthen** the arteries so they can **withstand high pressure**
      - Can **contract** or **relax** to control the diameter of the lumen and **regulate blood pressure**
    - The elastic tissue helps to **maintain blood pressure** in the arteries; it **stretches** and **recoils** to even out fluctuations in pressure when the heart beats
    - Further from the heart there is more smooth muscle and less elastic tissue due to smaller fluctuations in blood pressure
  - The outer layer covers the exterior of the artery and is mostly made up of **collagen** and **elastic fibres**
    - Collagen is a strong protein and protects blood vessels from damage by over-stretching
    - Along with elastic fibres, it prevents the arterial wall from rupturing as blood surges from the ventricles
- Arteries have a **narrow lumen** which helps to maintain high blood pressure

Artery structure diagram

Your notes

Your notes



Arteries have thick muscular walls and a narrow lumen

Arterial blood pressure

- Arteries, and to a slightly lesser extent arterioles, must be able to **withstand high pressure** generated by the contracting heart, and both must **maintain this pressure** when the heart is relaxed
- **Muscle** and **elastic fibres** in the arteries help to maintain the **blood pressure** as the heart contracts and relaxes
  - **Systolic pressure** is the peak pressure point reached in the arteries as the blood is forced out of the ventricles at high pressure
    - At this point the walls of the arteries are forced outwards, enabled by the **stretching** of elastic fibres
  - **Diastolic pressure** is the lowest pressure point reached within the artery as the heart relaxes
    - At this point the stretched elastic fibres **recoil** and force the blood onward through the lumen of the arteries
  - This maintains high pressure throughout the heart beat cycle
- Vasoconstriction of the circular muscles of the arteries can increase blood pressure by **decreasing the diameter of the lumen**
- Vasodilation of the circular muscles causes blood pressure to decrease by **increasing the diameter of the lumen**

Examiner Tip

Be careful with the language you use to describe the roles of muscle and elastic tissue; muscle can **contract** and **relax**, while elastic tissue can **stretch** and **recoil**.

Your notes

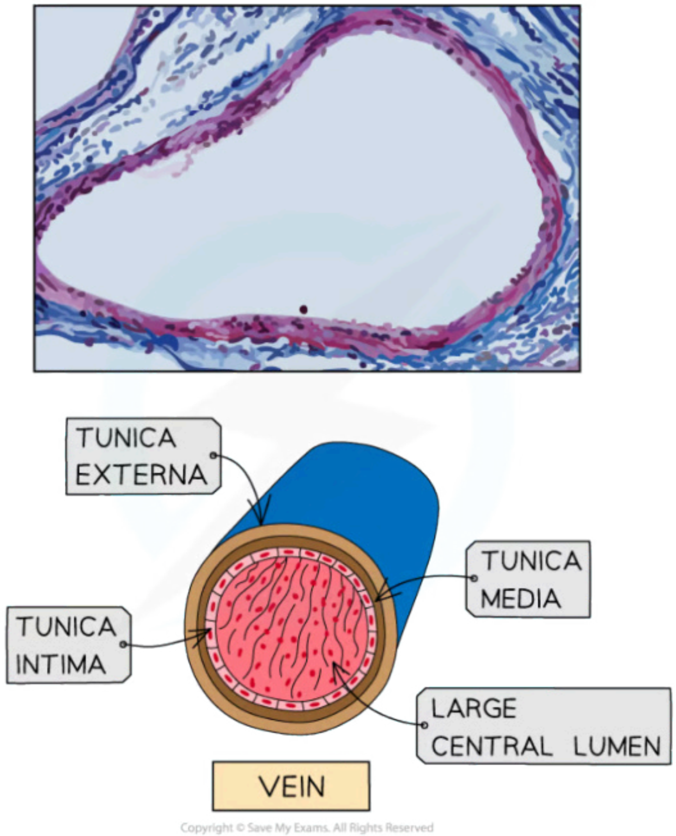
Veins

Adaptations of veins

Your notes

- **Veins** transport blood to the heart at **low pressure**
  - Remember; ve**in**s carry blood **in**to the heart
- They receive blood that has passed through capillary networks, across which **pressure has dropped** due to the slow flow of blood
  - The capillaries converge to form **venules**, which deliver blood to veins
- The structure of veins differs from arteries:
  - The middle layer is much **thinner** in veins
    - There is no need for a thick muscular and elastic layer as veins don't have to maintain or withstand high pressure
  - The walls of veins are **flexible**, allowing surrounding muscles and tissues to compress them
    - This facilitates the movement of blood back to the heart
  - Veins contain **valves**
    - These **prevent the back flow** of blood that can result under low pressure, helping return blood to the heart
    - Movement of the skeletal muscles pushes the blood through the veins, and any blood that gets pushed backwards gets caught in the valves; this blood can then be moved forwards by the next skeletal muscle movement
  - Veins have a **wide lumen**
    - This **maximises the volume** of blood that can flow at any one time

Vein structure diagram



Veins have thin walls and a wide lumen

Examiner Tip

For "explain" questions, remember to pair a description of a structural feature to an explanation of how it helps the blood vessel to function. For example, "capillaries have walls that are one-cell thick, enabling quick and efficient diffusion of substances due to a short diffusion distance."

Identify Blood Vessels: Skills

Your notes

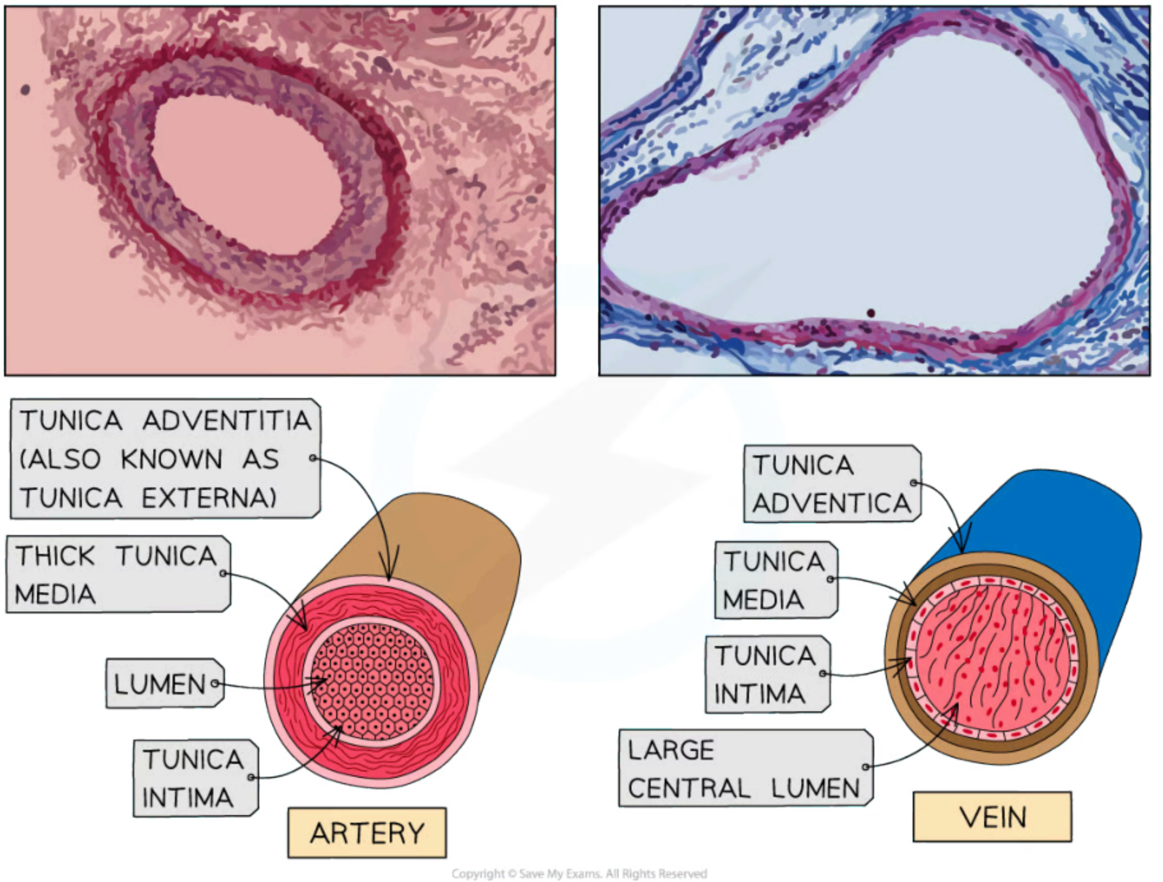
Structure of Arteries & Veins

Distinguishing arteries and veins in micrographs

- Arteries
  - The arterial walls are **much thicker and stronger** than those of veins
    - This is due to the presence of more collagen and elastic fibres, as well as a thicker layer of smooth muscle
  - The **lumen** of arteries is relatively **narrow** compared to the thickness of the wall
    - This maintains the blood pressure inside the arteries
- Veins
  - The walls of veins are **much thinner** than those of arteries
    - They do not need to withstand the high pressure present in arteries
  - The **lumen** of veins is much **wider in diameter** compared to the thickness of the wall
    - A larger lumen helps to ensure that blood returns to the heart at an adequate **speed**
      - A large lumen **reduces friction** between the blood and the endothelial layer of the vein
      - The rate of blood flow is slower in veins but a larger lumen means the **volume of blood delivered per unit of time is equal**
- These characteristics can be used to distinguish arteries and veins in micrographs

Artery and vein micrograph diagrams

Your notes



Arteries and veins can be distinguished from each other by the thickness of their walls and the diameter of the lumen; arteries (left) have thick walls and a narrow lumen while veins (right) have thin walls and a wide lumen

Note that you do not need to know the scientific names for the different tissue layers in the walls of the blood vessels

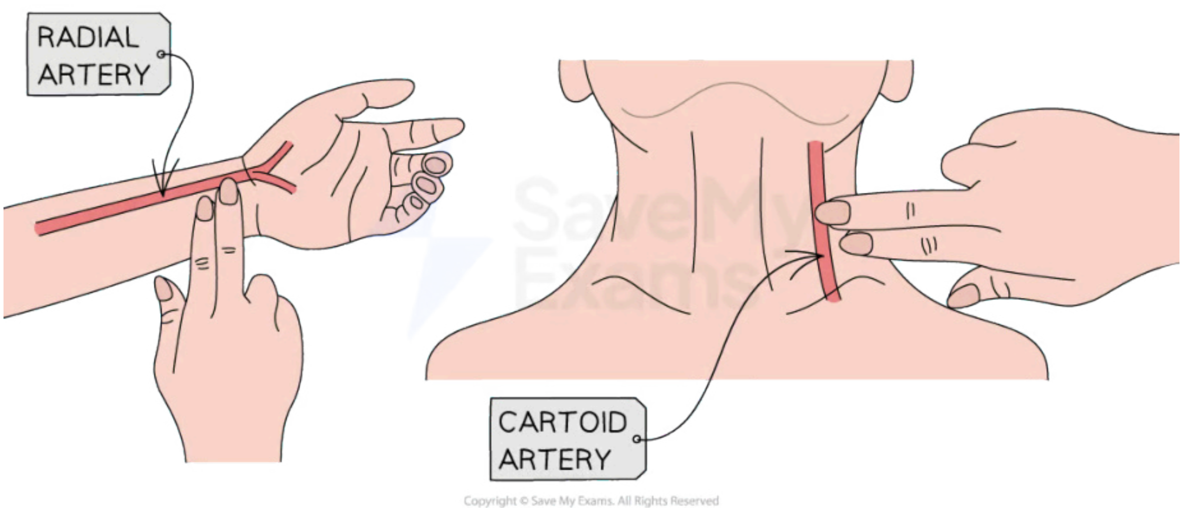
Your notes

Measuring Pulse Rate: Skills

Measuring Pulse Rate

- The contraction of the ventricles forces a large volume of blood through the arteries, which **expand** to accommodate this
- This can be felt as a **pulse**, especially in places where an artery is close to the skin surface or passes over a bone
  - For this reason, the **carotid artery** or **radial artery** can be used to measure pulse rate
    - The carotid artery runs down the side of the neck and a pulse can be felt just below the jaw
    - The radial artery passes over the wrist bones where a pulse can be felt just below the base of the thumb
- A pulse can be taken as follows:
  - Place **two fingers** on the radial or carotid artery and **gently compress** the blood vessel
  - **Count** the number of pulses felt for **60 seconds**
    - Alternatively, you could count for 30 seconds and multiply by 2
- Do not use your thumb when taking a pulse, since it also has a pulse that can lead to inaccurate results
- There are many **digital devices** that can also be used to determine pulse rate
  - These include data loggers, smartwatches or fitness bands
  - They scan the blood flow through the radial artery to measure pulse rate

Measuring pulse diagram



The radial or carotid artery can be used to measure the pulse rate

Coronary Heart Disease: Skills

Your notes

Coronary Heart Disease

- **Occlusion** of the arteries can be defined as

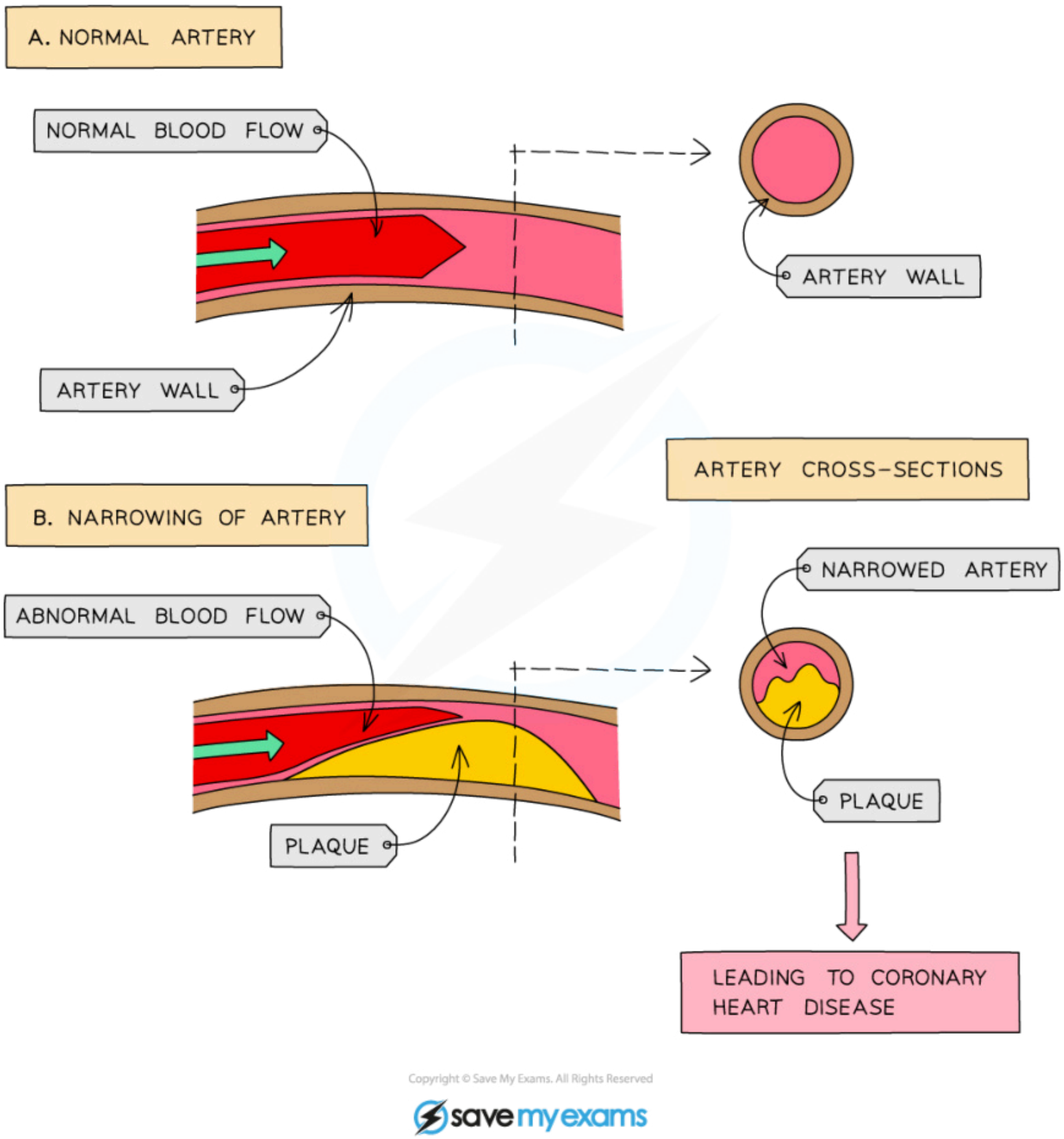
The narrowing of the arteries due to a blockage

- The arteries can be blocked by the process of **atherosclerosis**
  - **Atherosclerosis** begins when there is damage to the walls of the arteries due to high blood pressure
  - This damage can lead to the build-up of fatty deposits known as **atheromas** under the endothelium
  - These fatty deposits narrow the lumen of the artery, reducing the space for blood flow
- Atherosclerosis can lead to an **increase in blood pressure** within the artery, which causes further damage to the artery wall
  - **Fibrous tissue** is produced to repair the damage to the artery wall
    - This type of tissue is not elastic, so the overall elasticity of the artery wall is reduced
  - The smooth lining of the arteries breaks down and forms lesions called **plaques**
- This further damage can lead to the rupturing of blood vessel walls, which results in **blood clotting**
  - Clots formed within a blood vessel are called a **thrombus**
  - Once it circulates in the blood clots are known as an **embolus**

Consequences of atherosclerosis of the arteries

- When an embolus blocks a small artery or arteriole, tissues further down from the blockage do not receive the required level of **oxygen** and **nutrients**
  - This can **inhibit cell functions** and cause the cells to **die**
- If this happens in the **coronary arteries** then parts of the heart muscle die
  - This may stop the heart from pumping blood and lead to a **myocardial infarction**, or heart attack
- Blockages in the coronary arteries may be bypassed by undergoing **heart bypass surgery**
  - Blood vessels from the patient's leg are removed and used to create an alternative route for blood to flow past the blockage

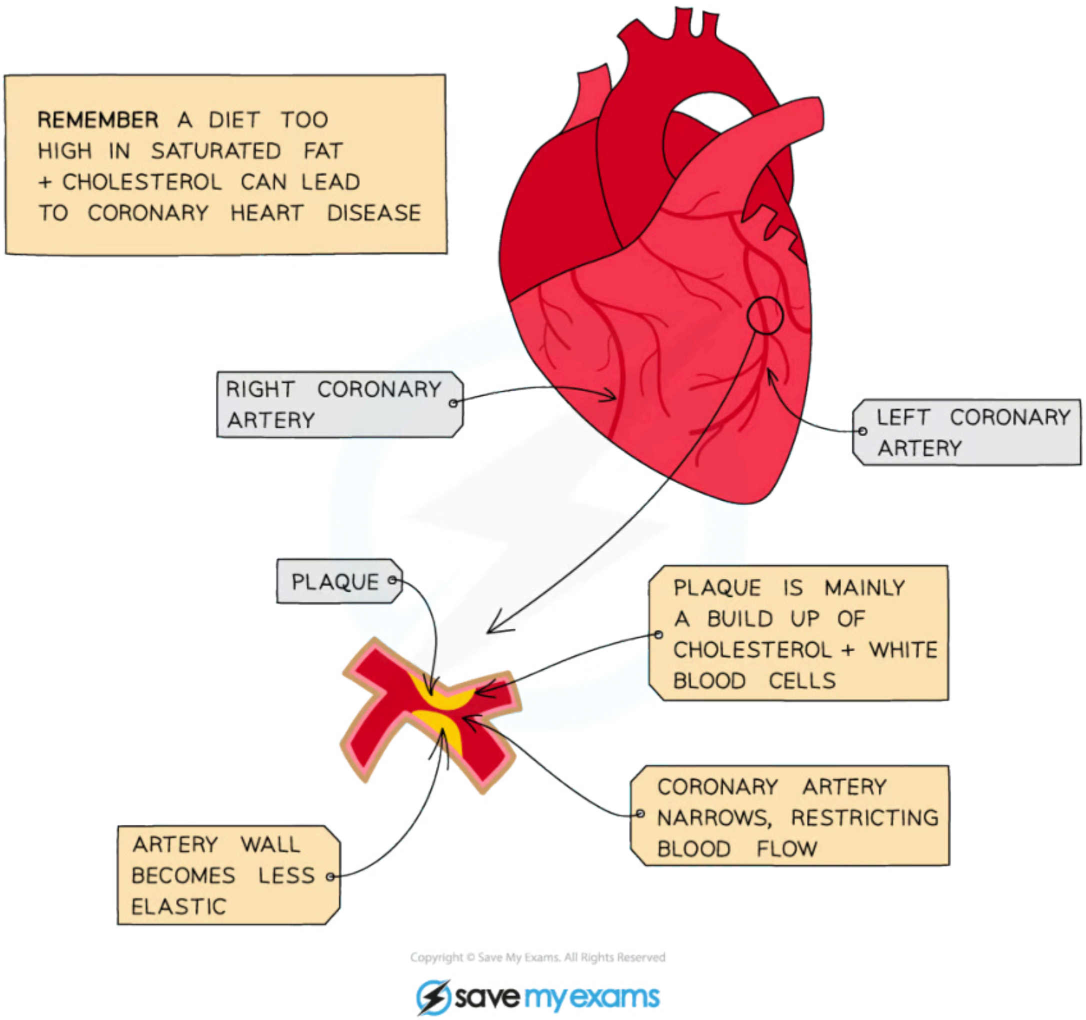
Atherosclerosis & coronary heart disease diagram



Atherosclerosis leads to narrowing of the arteries; this can lead to coronary heart disease

Your notes

Your notes



Buildup of plaque in the coronary arteries narrows the lumen, and can lead to a heart attack

Evaluating epidemiological data relating to the incidence of coronary heart disease

- Claims about the importance of different risk factors and coronary heart disease, e.g. a diet high in saturated fats, are based on:
  - **Epidemiological studies** on human populations
    - The evidence provide **correlation** data and so **do not** provide a definite causal link between coronary heart disease and risk factors such as saturated fat intake
  - **Clinical studies** of individual patients
    - Such studies are **small**, e.g. they may focus on just a few individuals, so they may not provide representative data
    - Studies will **not include a suitable controlled experiment** so it is not possible to make a definite causal link from the results

Your notes

- A controlled experiment would involve. e.g. one group of participants eating a normal diet while another group eats a diet high in saturated fat
- Ethical considerations would prevent such controlled experiments from being carried out, due to the risk of harm to a group consuming a high fat diet over a long period

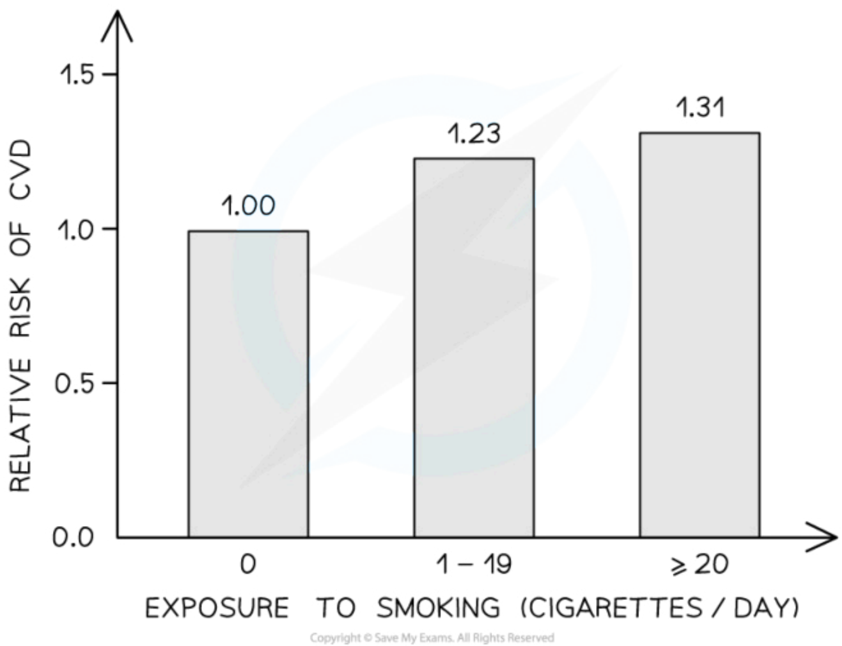
- When **evaluating** data from studies on coronary heart disease you could consider the following:
  - The sample group used must be **representative** of the population
    - **Larger sample sizes** are more likely to be representative as they cover a larger cross-section of the population
    - Samples must **not all come from the same demographic group**, e.g. not all white men who are over 60 and live in London
    - Samples must be **human**; results from animal trials do not perfectly represent human physiology
  - Statistical analysis should be used to check that any **differences between results are statistically significant**
    - E.g. the use of error bars in graphical data or the comparison of mean values from different trial groups
  - Some studies need to have a **control** with which to compare the results
    - E.g. when testing a drug to treat heart disease, a control group that is not given the drug should be included in the study to ensure that any effect shown is due to the drug and not any other factor
  - Studies should be **repeated**, or there should be **many studies that show the same result**, before conclusions can be drawn
  - The study should be designed to **control any variable that is not being tested**; this increases the **validity** of the results
    - Controlled factors might include, e.g. prior health of participants, other lifestyle factors of participants such as exercise and stress levels, age of participants, and biological sex of participants
    - Results are considered to be valid if they **measure what they set out to measure**, i.e. they are not influenced by external variables or poor experimental design, and have been analysed correctly
  - Researchers should **not be biased**, i.e. looking for a particular outcome
    - This could be a problem if someone is being paid to come up with a particular result
  - **Data collection methods** must be accurate, e.g. participants may not tell the truth in a questionnaire about diet or exercise

Your notes

Worked example

A study was carried out into the relative risk of heart disease (CVD) in non-smoking adults exposed to a range of levels of cigarette smoke from a smoking partner. The study looked at 523 non-smoking partners of smokers.

The results are shown in the graph below



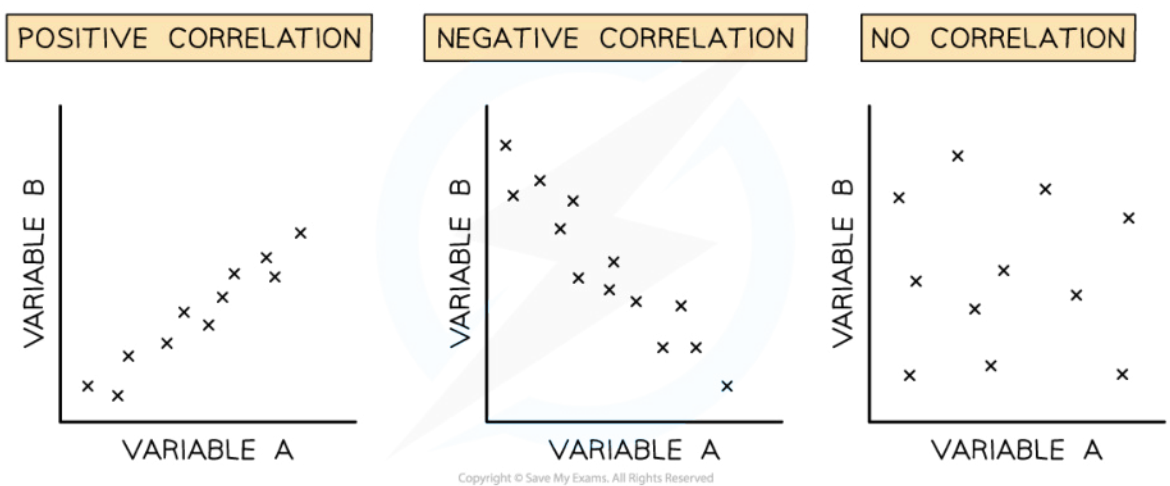
Evaluate the validity of the data

- A commentary on the **validity** of the data could include
  - The study included 523 people; this is a fairly **small sample size** and may not represent an entire population
  - This is only one study; **more studies would need to be carried out** to back up these results
    - Being able to replicate the results of a study shows that the results are reliable
  - There is no information on **how other risk factors might be interacting with smoking** to influence the risk of CVD
    - Risk factors such as age, diet, biological sex, or exercise levels may be playing a role, as these factors may be interacting with the smoking variable e.g.
      - Smokers are often older
      - More men may smoke than women
      - Smokers may be less likely to exercise
  - The data doesn't comment on the **use of any statistical tests** so we cannot state the significance of the differences between the different levels of smoke exposure

NOS: Correlation coefficients quantify correlations between variables and allow the strength of the relationship to be assessed

Your notes

- Sometimes **correlation** between two variables can appear in the data
  - **Correlation** is an association, or relationship, between variables
  - There is a clear distinction between **correlation** and **causation**: a correlation does not necessarily imply a causative relationship
    - **Causation** occurs when one variable has an influence on, or is influenced by, another
- In order to get a broad overview of the correlation between two variables the data points for both variables can be plotted on a **scatter graph**
- Correlation can be **positive or negative**
  - Positive correlation: as variable A increases, variable B increases
  - Negative correlation: as variable A increases, variable B decreases
- The correlation coefficient (r) can be calculated; this indicates the **strength of the relationship** between variables
  - Perfect correlation occurs when **all of the data points lie on a straight line** with a **correlation coefficient of 1** or **-1**
    - Remember that even strong correlations do not imply a causal relationship between the variables
  - The closer the correlation coefficient is to 1 or -1, the stronger the relationship
  - If there is **no correlation** between variables the **correlation coefficient will be 0**
- **Low** correlation coefficients or **no** correlation between variables may provide evidence **against** a hypothesis



Scatter graphs can be used to show the correlation between variables

The Transpiration Stream

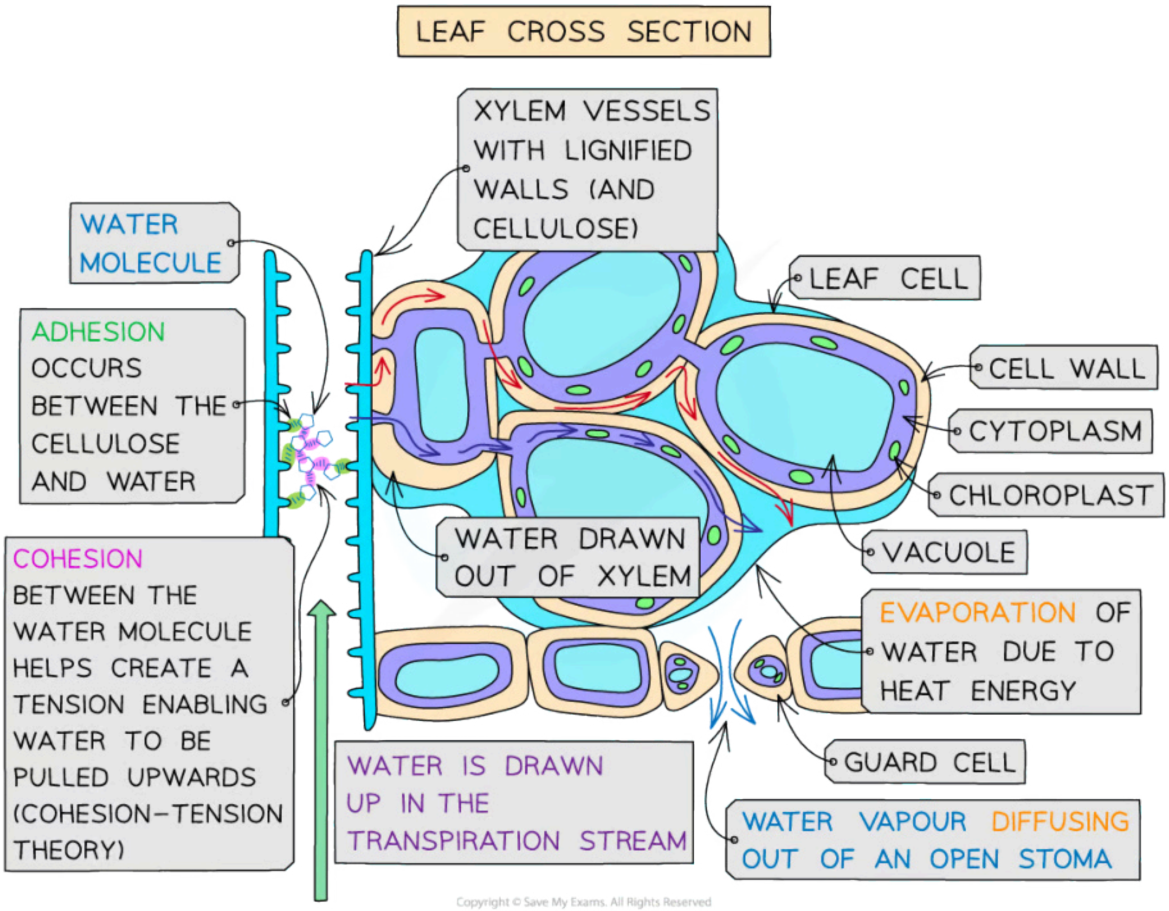
Your notes

The Transpiration Stream

- When water **evaporates** from the surfaces of cells inside a leaf during transpiration, more water is **drawn from the nearest xylem vessels** to **replace the water lost** by evaporation
  - Water molecules adhere **to the cell walls of plant cells** in the leaf, enabling water to move through the cell walls
    - Here the water moves through the cell walls of the xylem into other cells of the leaf
  - This movement of water that occurs due to adhesion to the walls of a narrow tube is **capillary action**
- The loss of water from the xylem vessels **generates tension** (negative pressure) within the xylem
- The tension generated in the xylem when water moves into the cells in the leaves creates a **pulling force** throughout the xylem vessels that is transmitted, via cohesion **between water molecules**, all the way down the stem of the plant and to the ends of the xylem in the roots
  - This is known as **transpiration pull** and it allows water to be moved upwards through the plant, against the force of gravity
- This is sometimes known as the cohesion-tension theory of transpiration
- This continuous upwards flow of water in the xylem vessels of plants is known as the **transpiration stream**

Water transport in plants diagram

Your notes



The movement of water through xylem vessels is due to the evaporation of water vapour from the leaves and the cohesive and adhesive properties exhibited by water molecules

- Transpiration is important to the plant in the following ways
  - It provides a means of **cooling** the plant via evaporative cooling
  - The transpiration stream is helpful in the **uptake of mineral ions**
  - The turgor pressure of the cells (due to the presence of water as it moves up the plant) provides **support** to leaves (enabling an increased surface area of the leaf blade) and the stem of non-woody plants

Your notes

Adaptations of Xylem Vessels

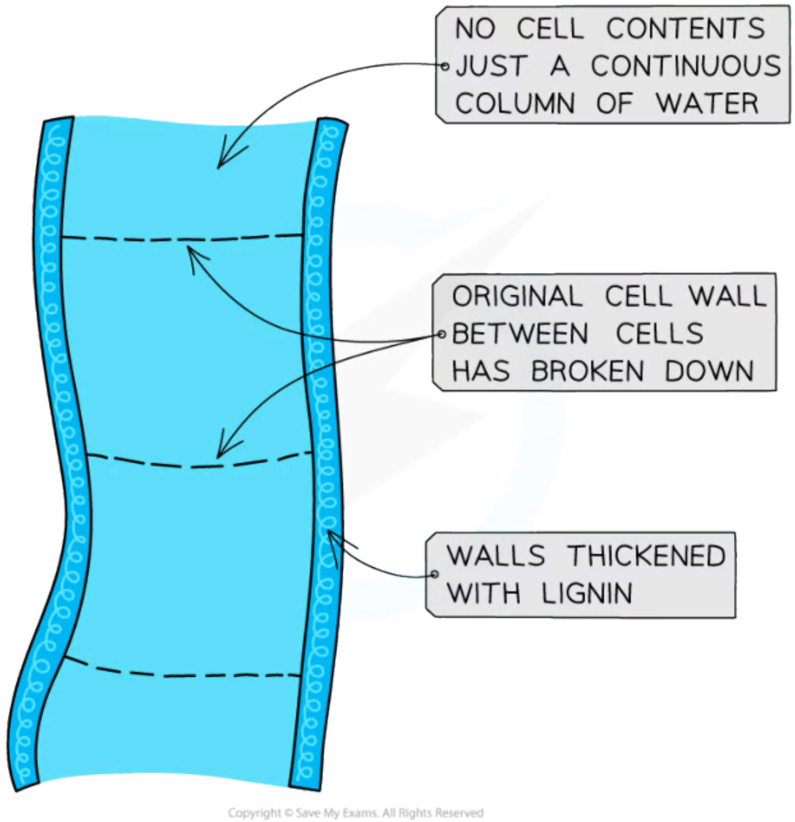
Adaptations of Xylem Vessels

- The transport of water occurs in xylem vessels, one of the vascular tissues found within plants
  - Along with water, xylem vessels are also responsible for the transport of mineral ions from the roots
- The cohesive property of water, together with the structure of the xylem vessels, allows water to be transported under tension from the soil to the leaves

Xylem vessel adaptations

- Xylem vessels are formed from **long lines of cells** that are connected at each end
  - Mature xylem vessels are **non-living** cells
- As the xylem cells develop the **cell walls between the connected cells degrade** and the **cell contents are broken down**
  - This forms **mature xylem vessels** that are **long, continuous, hollow tubes** that lack cell content and end walls
  - This allows for **unimpeded flow** through the xylem vessels
- The walls of xylem vessels are **thickened with cellulose** and **strengthened with a polymer called lignin**
  - This means xylem vessels are extremely tough and can **withstand very low internal pressures**, i.e. negative pressure (tension), **without collapsing** in on themselves
- Xylem vessel walls contain tiny pores called **pits** which allow water to enter and move sideways between vessels
  - This means that if a vessel is damaged, the water can flow into another vessel and still reach the leaves

Xylem structure diagram



Xylem vessels are adapted to transport water from the roots to the leaves in plants

Your notes

Drawing Root & Stem Structure: Skills

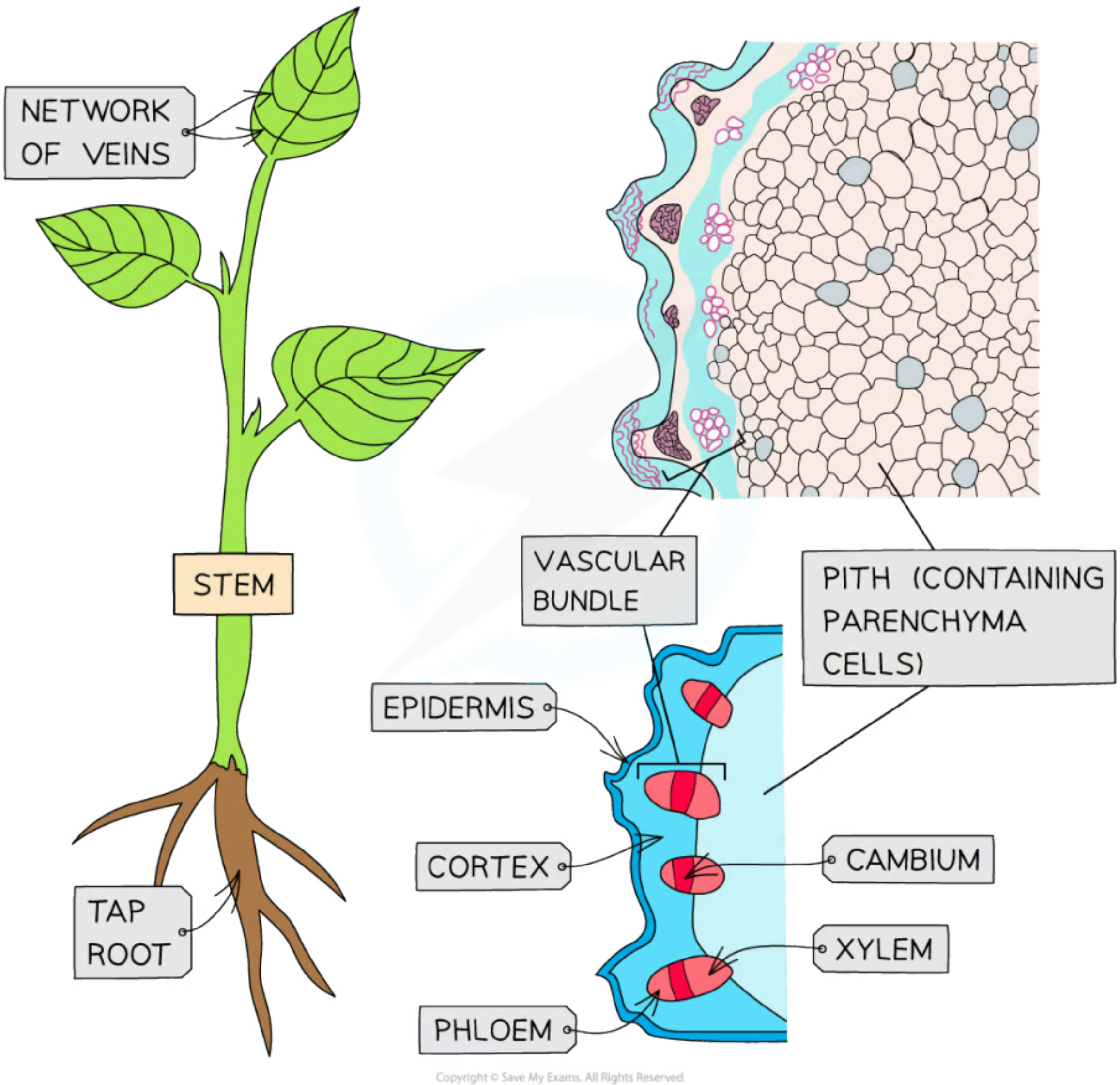
Your notes

Dicotyledonous Stem Structure

Distribution of tissues in a transverse section of a dicotyledonous stem

- The stem in a dicotyledonous plant contains several different types of tissues, which include:
  - The **epidermis** which forms the outer layer of the stem
    - This prevents water loss and provides protection from herbivores
  - **Parenchyma** which forms the **cortex** and **pith** of the stem
    - These cells act as **storage structures** for starch and other substances
    - The cortex is the region located directly beneath the epidermis while the pith is the central region of the stem
  - **Vascular tissue** arranged in a ring of vascular bundles
    - **Xylem** transports **water** and **dissolved mineral ions** from the roots to the leaves
    - **Phloem** transports **organic solutes** from the leaves to other parts of the plant
- The distribution of tissues in a transverse section of a dicotyledonous stem can be represented as a **plan diagram**
- There are a few things to keep in mind when drawing plan diagrams:
  - Do not draw individual cells; only the **outline** of different tissues are drawn
  - Draw **clear**, **continuous lines**; do not sketch
  - **Avoid shading** parts of your drawing
  - Pay attention to the **size and proportions** of different parts visible in a micrograph
  - Make sure the different parts are **clearly labelled**
  - Add a **scale bar** or the **estimated size** of your drawing
  - Include **annotations** that give the functions of the labelled sections

Your notes



A plan diagram (bottom right) showing the distribution of different tissues in a dicotyledonous stem

Note that a hand-drawn plan diagram should not contain shading

Examiner Tip

You are expected to **annotate** your drawing with the main functions of these structures; this is not shown above

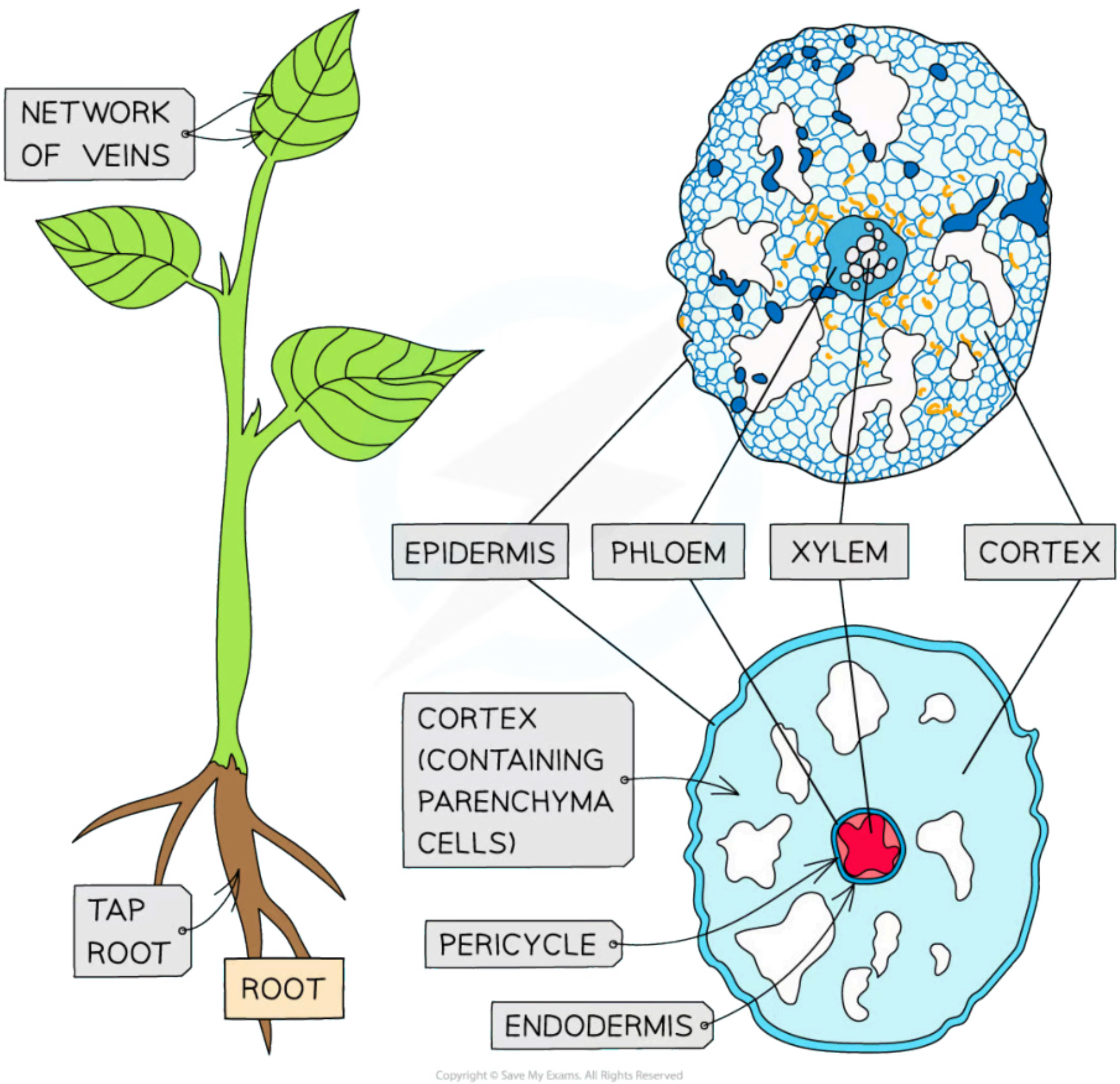
Dicotyledonous Root Structure

Distribution of tissues in a transverse section of a dicotyledonous root

- The arrangement of the **vascular tissues** differ in a **root** compared to a stem
  - The **xylem** is centrally located in a root in a cross-shaped structure, while it forms the outer part of the ring of vascular bundles in a stem
    - Remember, x = a cross = **x**ylem
  - **Phloem** bundles are arranged between the cross "arms" of xylem in a root, while it forms the inner part of the ring of vascular bundles in a stem
- The **cortex** consists of parenchyma cells that store starch and other substances while the **epidermis** forms the outer layer of the root
  - Specialised epidermal cells called **root hairs** are present in roots to absorb water and mineral ions from the soil
- The **endodermis** forms the boundary between the vascular tissue and cortex in a root
- You should be able to **draw a plan diagram** of the tissues in a dicotyledonous root; see above for the features of a plan diagram drawing

Your notes

Your notes



A plan diagram (bottom right) of a dicotyledonous root showing the distribution of different tissues

Note that hand-drawn plan diagrams should not contain any shading

Examiner Tip

Don't forget to draw your plan diagrams large enough to fill at least half of the available space on a page. Making a drawing that is too small will make it difficult to label structures accurately and may cost you marks