St. Ambrose College

A Level Biology (Year 12)

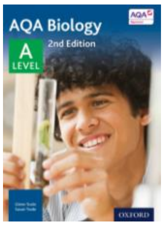
Knowledge Organiser: Unit 3 Organisms exchange

3.4.1 Mass transport in Plants

For every 1 hour A Level Biology lesson you are expected to spend at least 1 hour independently reviewing the subject content. The following resources should be referred to regularly to support your independent work.

You have been provided with a printed copy of the full subject specification (also available on the AQA website https://www.aqa.org.uk/subjects/science/as-and-a-level/biology-7401-7402/specification-at-a-glance). Use this to follow the learning in lessons…track your progress and be aware of what is still to come.

kerboodle



Use the textbook on www.kerboodle.com after every lesson to develop your understanding. Read the relevant pages, add detail to your class notes and complete the summary tasks. Create your own summary notes/flashcards for future use in the run up to exams.

Unit 3 Organisms exchange on pages 128-199 Mass transport in plants (pg183-198)

SENECA www.senecalearning.com

Use regularly between lessons to review basic content and to become more familiar with key terminology. https://senecalearning.com/en-GB/

PMT •resources•tuition•courses

Access detailed revision notes, key definitions, flash cards, past paper questions and mark schemes. https://www.physicsandmathstutor.com/biology-revision/a-level-aqa/

As an A Level student you are expected to take a proactive approach to your studies; arrive to lessons fully equipped and prepared for what you will be learning about (read ahead in the specification/textbook), focus and participate in lessons, ask for help/clarification when you are unsure and spend time after the lesson consolidating/embedding new learning.

3.4.2 Mass transport in plants

Xylem is the tissue that transports water in the stem and leaves of plants

The cohesion-tension theory of water transport in the xylem

- Cohesion tension theory: How water moves up the xylem against gravity via the transpiration stream
- Water evaporates from the leaves via the (open) stomata due to transpiration
- Reducing water potential in the cell and increasing water potential gradient
- Water drawn out of xylem
- Creating tension
- Cohesive forces between water molecules pull water up as a column
- Water lost enters the roots via osmosis
- Water is moving up, against gravity
- Water is also cohesive so sticks to the edges of the column

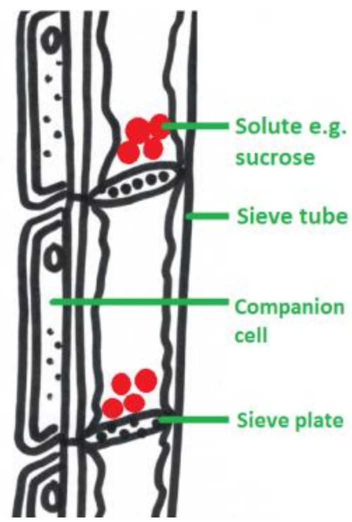
Adaptations of the xylem

- Elongated cells arranged end to end to form a continuous column
- Hollow due to lignification so no cytoplasm/nucleus to slow water flow
- End walls break down for flow
- Thick cell walls with lignin
- Rigid so less likely to collapse under low pressure
- Waterproof preventing water loss
- Pits allow lateral water movements
- Narrow lumen increases height water can rise due to cohesion tension/ capillary action

Phloem is the tissue that transports organic substances in plants

The mass flow hypothesis for the mechanism of translocation in plants

- Translocation:
    - Movement of solutes/ assimilates from source to sink/ one place to another
    - E.g. sugars made from photosynthesis in the leaves are transported to the site of respiration
- At the source:
    - High concentration of solute
    - Active transport loads solutes from companion cells to sieve tubes of the phloem
    - Lowering the water potential inside the sieve tubes
    - Water enters sieve tubes by osmosis from xylem and companion cells
    - Increasing pressure inside sieve tubes at the source end
- At the sink:
    - Low concentration of solute
    - Solutes removed to be used up e.g. enzymes hydrolyse
    - Increasing the water potential inside the sieve tubes
    - Water leaves tubes via osmosis
    - Lowering pressure inside sieve tubes
- Mass flow:
    - Pressure gradient from source to sink
    - Pushes solutes from source to sink
    - Solutes used or stored at the sink e.g. respiration



Adaptations of the phloem

- Sieve tube elements have no nucleus and few organelles
- Companion cell for each sieve tube element to carry out the living functions for the sieve cells i.e. ATP for active transport of solutes

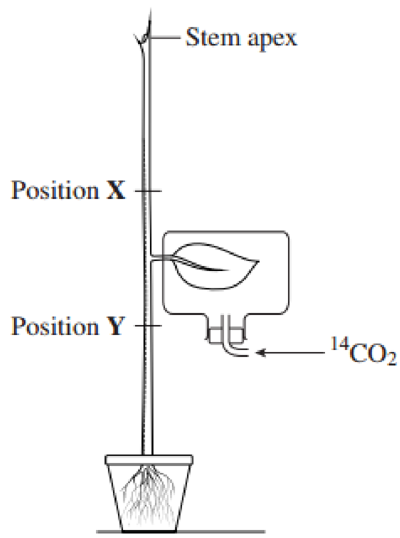
The use of tracers and ringing experiments to investigate transport in plants. Evaluating the evidence for and against the mass flow hypothesis

- Use of tracers
    - Supply plant with radioactive tracer such as ^{14}C in CO_2 to a photosynthesising leaf by pumping the radioactive CO_2 into a container surrounding the leaf
    - ^{14}C is incorporated into the organic substances produced by the leaf e.g. sugars via photosynthesis
    - Organic substances undergo translocation
    - Autoradiography – plant killed and placed in a photographic film, film turns black where the radioactive substance is present
    - Identifies where radioactive substance has moved to and thus where the organic substances have moved to via translocation from source to sink
    - Can show this over time by taking autoradiographs at different times

Example exam question:

Scientists investigated the movement of organic substances in four plants, A, B, C and D. One leaf from each plant was supplied carbon dioxide containing the radioactive isotope of carbon, ^{14}C. Figure 1 shows one of these plants. Each plant was treated differently before it was supplied with the radioactive isotope. A was ringed at position X, B at position Y, C at X and Y and D wasn't ringed.

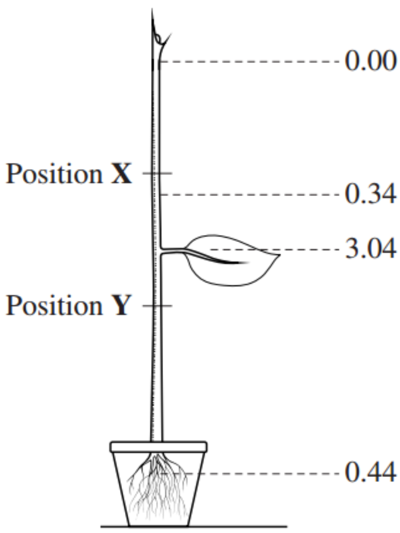
Figure 1



(a) *All 4 plants were kept in bright light for one hour.*
Explain why. ***(1 mark)***

✓ *Rapid photosynthesis to produce radioactive sugars*

Figure 2



(b) *Figure 2 shows the distribution of 14C after one hour in one of these plants.*
Which plant (A,B,C or D) is shown in figure 2?
Explain your answer. ***(3 marks)***

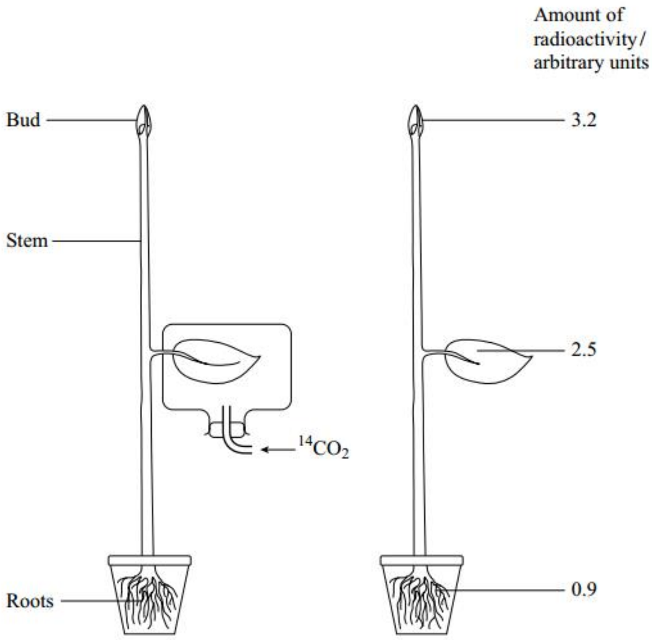
✓ *Plant A*
✓ *No 14C at top of plant (so ringed at X)*
✓ *14C in roots (so not ringed at Y)*

(c) *Using the information give,* ***explain the purpose of including plant D in the investigation.*** ***(1 mark)***

✓ *To compare distribution with an unringed plant / phloem present (accept: control if qualified)*

Example exam question:

One leaf on a young plant was supplied with carbon dioxide containing the radioactive isotope of carbon. The plant was kept in bright light for one hour. The amount of radioactivity was then measured at three places in the plant. The diagram shows the results. Only the treated leaf is shown.



(a) ***Suggest one explanation for the difference in the amount of radioactivity in the bud and the roots.*** ***(2 marks)***
- ✓ *More carbohydrate transported to bud than root*
- ✓ *Carbohydrate needed for growth / high growth rate in bud*
- ✓ *Carbohydrate needed for respiration / to release energy/ATP*
- ✓ *Synthesis of molecules e.g.…*

(b) ***Suggest why some radioactivity remains in the leaf.*** ***(1 mark)***
- ✓ *Remains in organic molecules in lead / not enough time for removal*

(c) ***Describe how a ringing experiment could be carried out to determine which tissue transports the substances containing the radioactive carbon.*** ***(3 marks)***
- ✓ *Remove / kill phloem*
- ✓ *Named technique / method for measuring radioactivity e.g. use of radiography / analysis of feeding aphids / Geiger counter*
- ✓ *If no radioactivity passes ring, transport is via phloem*

Alternative experiment: Aphid

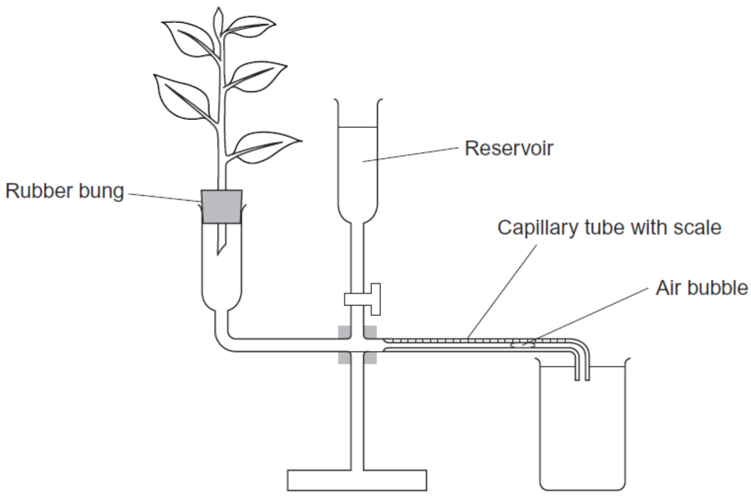
- Aphids pierce the phloem using mouthpiece
- Releasing sap from plants
- Flow of sap higher at leaves/source than further down/ sink
- Evidence of a pressure gradient; higher pressure near source

Alternative experiment: Metabolic inhibitor

- Add a metabolic inhibitor to phloem
- Translocation stops
- Proves active transport is involved
- As it requires ATP to move against a concentration gradient

Setting up and using a potometer to investigate the rate of transpiration

- Potometer estimates the transpiration rate by measuring water uptake
    - Assume that water uptake is directly related to the water loss of the leaves
- Method:
    - Cut a shoot underwater
        - To prevent air entering xylem → interrupt water flowing in column, stopping transpiration
    - Assemble potometer with capillary tube end submerged in a beaker of water
    - Insert shoot underwater
    - Ensure apparatus is watertight and airtight
    - Dry leaves and allow time for the shoot to acclimatise
    - Shut off tap to reservoir
    - Remove the end of the capillary tube from the water beaker until one hair bubble has formed, then put the tube back into the water
    - Record the position of the air bubble
    - Use a stopwatch to record time e.g. one minute
    - Record distance moved per unit time
    - Rate of air movement = estimate of transpiration rate
    - Change one variable at a time and keep all other variables constant (wind, humidity, light and temperature)



Different environmental variables affect the transpiration rate:

Light
- The higher the light intensity, the faster the transpiration rate (positive correlation)
- Because stomata open in light to let in CO_2 for photosynthesis
- Allowing more water to evaporate faster
- Stomata close when it's dark so there is a low transpiration rate

Temperature
- The higher the temperature, the faster the transpiration rate (positive correlation)
- Water molecules gain kinetic energy as temperature increases
- Move faster
- Water evaporates faster

Humidity
- The lower the humidity, the faster the transpiration rate (negative correlation)
- Because as humidity increases, more water is in the air so it has a higher water potential
- Decreasing the water potential gradient from leaf to air
- Water evaporates slower

Wind
- The windier, the faster the transpiration rate (positive correlation)
- Wind blows away water molecules from around the stomata
- Decreasing the water potential of the air around the stomata
- Increasing the water potential gradient
- Water evaporates faster