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AS and A LEVEL

Delivery Guide

BIOLOGY A

H020/H420
For first teaching in 2015

Transport in plants 3.1.3

Version 2

www.ocr.org.uk/biology

Introduction

AS and A LEVEL *BIOLOGY A*

Delivery guides are designed to represent a body of knowledge about teaching a particular topic and contain:

- Content: A clear outline of the content covered by the delivery guide;
- Thinking Conceptually: Expert guidance on the key concepts involved, common difficulties students may have, approaches to teaching that can help students understand these concepts and how this topic links conceptually to other areas of the subject;
- Thinking Contextually: A range of suggested teaching activities using a variety of themes so that different activities can be selected which best suit particular classes, learning styles or teaching approaches.

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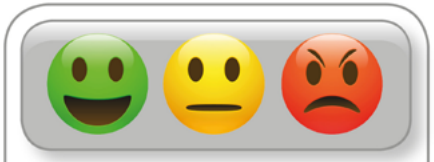

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Curriculum content

3.1.3 Transport in plants

(a)	the need for transport systems in multicellular plants	To include an appreciation of size, metabolic rate and surface area to volume ratio (SA:V). *M0.1, M0.3, M0.4, M1.1, M2.1, M4.1* HSW1, HSW3, HSW5, HSW8
(b)	**(i)** the structure and function of the vascular system in the roots, stems and leaves of herbaceous dicotyledonous plants	To include xylem vessels, sieve tube elements and companion cells.
	(ii) the examination and drawing of stained sections of plant tissue to show the distribution of xylem and phloem	**PAG1** HSW4
	(iii) the dissection of stems, both longitudinally and transversely, and their examination to demonstrate the position and structure of xylem vessels	**PAG2** HSW4
(c)	**(i)** the process of transpiration and the environmental factors that affect transpiration rate	To include an appreciation that transpiration is a consequence of gaseous exchange.
	(ii) practical investigations to estimate transpiration rates	To include the use of a potometer. *M0.1, M0.2, M1.1, M1.2, M1.3, M1.6, M1.11, M3.1, M3.2, M3.3, M3.5, M3.6, M4.1* **PAG5, PAG11** HSW2, HSW3, HSW4, HSW5, HSW6, HSW8
(d)	the transport of water into the plant, through the plant and to the air surrounding the leaves	To include details of the pathways taken by water **AND** the mechanisms of movement, in terms of water potential, adhesion, cohesion and the transpiration stream. HSW2, HSW8
(e)	adaptations of plants to the availability of water in their environment	To include xerophytes (cacti and marram grass) and hydrophytes (water lilies). HSW2
(f)	the mechanism of translocation.	To include translocation as an energy-requiring process transporting assimilates, especially sucrose, in the phloem between sources (e.g. leaves) and sinks (e.g. roots, meristem) **AND** details of active loading at the source and removal at the sink. HSW2, HSW8

The Transport in Plants section of the specification covers the following areas:

- basic principles (a)
- histology of transport tissues (b)
- water loss (transpiration) (c)
- water entry (d)
- adaptations to aquatic and dry environments (e)
- sucrose transport (f).

Theory teaching materials are listed in the first section here, ideas relating to the more challenging mathematical or philosophical aspects in the second (concepts) section, and practical activity ideas and unusual approaches in the third (contexts).

Activities

Activity 1
Transport in multicellular plants interactive flashcards (Cram.com)
http://www.cram.com/flashcards/biology-10-transport-in-multicellular-plants-999773

This site (and associated app to download to smartphones) specialises in generating flashcards for revision. The link here is for basic questions and answers about the need for transport in multicellular plants. Related sets of flashcards are shown at the top right of the page. These cards could be used on the white board for whole class revision, or if students like the idea they can sign up and add their own flashcards and customise the resource.

Activity 2
Transpiration (Pearson)
http://www.phschool.com/science/biology_place/labbench/lab9/intro.html

This is a step by step introduction to the topic with animations. Hydrogen bonding in water is explained (synoptic link with 2.1.2(a)). The level of detail provided about the mechanisms of action of guard cells may be too much here but again there is a synoptic link, to 2.1.6(h).

Activity 3
Stomata Video Clip (BBC)
http://www.bbc.co.uk/education/clips/zf3xn39

A 1 minute clip with botanist Timothy Walker from 2011. This clip was sourced from the new BBC site which combines video clips and classroom resources with learner materials up to GCSE level (formerly 'Class Clips' and 'Bitesize').

http://www.bbc.co.uk/education

Activity 4
Private Life of Plants, Transpiration Clip (BBC)
https://www.bbc.co.uk/programmes/p00lxt8k

This is a short extract summarising transpiration, featuring an excellent 3D animation of the vascular tissues. It is taken from near the beginning of episode 2 of the six part 1995 series The Private Life of Plants narrated by David Attenborough. The section starts with David Attenborough high up next to a tree in a fire brigade cherry picker, discussing the power required to pump water to this height in a fireman's hose. The whole series can be found at https://www.bbc.co.uk/programmes/b01qbw1w/episodes/guide. These clips can generate an interesting conversation about the accuracy of popular science television.

Activity 5
Transport of water in plants animation (SAPS)
http://www.saps.org.uk/secondary/themes/1274

SAPS provide a summary animation showing water and sucrose movement at various points in the plant, e.g. root, stem and leaf. It is non-narrated so provides a moving background for teachers or students to narrate. The link includes teacher notes, a student revision guide and a link to a video which allows the animations to be viewed on mobile devices.

Activity 67
Xerophytes Adaptations (Quizlet)
http://quizlet.com/34232877/92-xerophytes-adaptations-some-plant-mineral-movement-flash-cards/

This site can be used for information, flashcards or as a quiz. There are various options to customise learning for individuals
or a class.

Activity 7
Hydrophytes (Quizlet)
http://quizlet.com/42602323/by2-hydrophytes-flash-cards/

This site can be used for information, flashcards or as a quiz. There are various options to customise learning for individuals
or a class.

Activity 8
Phloem Loading Animation (McGraw-Hill)
http://highered.mheducation.com/sites/9834092339/student_view0/chapter38/animation_-_phloem_loading.html

This is a narrated animation on translocation.

Thinking conceptually

Approaches to teaching the content

One of the biggest problems to overcome is the low level of interest the majority of students have in plant physiology. They also tend to be put off by the language of plant histology (e.g. sclerenchyma, collenchyma) and have trouble seeing differences between different plant cells. On the plus side, plant cells are bigger than animal cells and so easier to see, with distinct cell walls that can be clearly stained to show their thickness (a key point in identification of different types). Students also like practical work. Well-supported microscopy work with labelled images on the white board or on worksheets is essential for students to find their way around plant anatomy. The use of prepared slides should be complemented by some dissection of plants so that students can find their way round the different tissues and organs for themselves. The sheet 'The weirdness of plants' gives ideas for raising students' curiosity about how plants live. Associating water transport in the xylem with desert survival, and sucrose transport in the phloem with products like maple syrup, gives an anthropocentric point of reference for exploration of the mechanisms of transpiration and translocation.

Common misconceptions or difficulties students may have

The main difficulty seen in exam answers is a lack of detail in student answers, and a lack of precision about parts of cells and plant tissues when describing the mechanism of water movement across the root, the transpiration pull and active loading of sucrose at sources. Terms like osmosis, active transport and diffusion need to be used appropriately, and a biochemical level of detail is needed to describe hydrogen ion and sucrose co-transport at companion cells for instance.

Conceptual links to other areas of the specification – useful ways to approach this topic to set students up for topics later in the course

Background topics

2.1.1 (b) light microscopy

2.1.2 (a) the properties of water

2.1.2 (e) sucrose

2.1.5 (d) and (e) movement of molecules across cell membranes

Later topics which require understanding from 3.1.3

4.1.1 (a), (b) and (c) plant pathogens

4.2.2 (g) adaptation to a habitat (xerophytes, hydrophytes)

5.1.5 (a)-(f) plant hormones (and their modes of transport)

5.2.1 (f) uses of triose phosphate from photosynthesis

5.2.2 (a) why plants need to respire (relate to translocation to sinks, e.g. roots, fruits)

6.2.1(a) production of viable cuttings requires understanding of the significance of the transport tissues and limiting water loss by transpiration

6.3.2(d) syrup tapping in North American forests provides an example of sustainable exploitation of a resource in an ecosystem.

Activities

Learner Activity 1
Vascular Plants – Winning (Crash Course Biology 37) DFTBA via YouTube
https://www.youtube.com/watch?v=h9oDTMXM7M8

The success of vascular plants based on their transport tissues is animatedly described by gifted communicator Hank Green in this 12 minute clip. It would provide a good introductory context to section 3.1.3 Transport in plants. There is a useful table of contents showing what the video covers under 'Show More' on the YouTube platform. An index to the full selection of 40 Crash Course Biology videos can be seen at:

https://www.youtube.com/watch?v=QnQe0xW_JY4&list=PL3EED4C1D684D3ADF

Learner Activity 2
The Weirdness of Plants (OCR)
This sheet provides some talking points and a suggested activity to improve levels of student interest in plant physiology. It could be combined with the Crash Course Biology video.

Learner Activity 3
How to Calculate Leaf Surface Area (Pearson)
http://www.phschool.com/science/biology_place/labbench/lab9/calcsurf.html

This could be used conceptually in connection with gas exchange data, or practically in transpiration experiments (supporting module 1 and/or **PAG5, PAG11**) or in relation to counting stomata and finding a mean (mathematical skill *M1.2*) per unit area (mathematical skill *M4.1*).

Learner Activity 4
Measuring Rate of Water Uptake using a Potometer (Nuffield Foundation)
https://pbiol.rsb.org.uk/exchange-of-materials/transpiration-in-plants/measuring-rate-of-water-uptake-by-a-plant-shoot-using-a-potometer

This provides comprehensive advice for the teacher on running a class practical using potometers, with suggestions of factors affecting transpiration that students can investigate. A student sheet can be downloaded. The calculation of rates of water uptake and the cross-sectional area of the capillary tube to calculate volumes of water taken up allow practice of mathematical skills *M1.1* and *M4.1*. Data obtained can also be analysed to find a mean (*M1.6*), plot bar charts or graphs (*M3.2*) and to find the percentage error (*M1.11*). This would also support the teaching of many of the practical learning outcomes in module 1.

Learner Activity 5
Stomatal Opening and Closing in *Commelina communis* (SAPS)
https://www.stem.org.uk/resources/elibrary/resource/83332/stomatal-opening-and-closing-commelina-communis

Practical instructions to investigate stomatal opening and closing are provided on a teacher sheet, with accompanying
student sheet.

Learner Activity 6
Map of Life – Succulent Desert Plants (University of Cambridge Map of Life)
http://www.mapoflife.org/topics/topic_385_succulent-desert-plants/

This examination of succulent xerophytes focuses on convergent evolution producing the same adaptations in different parts
of the world (linking to 4.2.2g). Conceptual understanding of convergence would be needed.

Thinking contextually

Contexts

The contexts listed include using bananas as a source of xylem for microscopy, some fun activities with cut flowers, finding out about harvesting phloem translocate from trees, and how to use transpiration as a way of obtaining drinking water from plants.

Activities

Learner Activity 1
Banana Xylem Activity
An easy way to see annular and helical xylem and to practise microscopy skills (supporting module 1 and **PAG1**) is the following: Peel a banana and take the stringy bits that fall away from the banana. Cut a small section of this string and lay it on a microscope slide. Squash down well with a coverslip (consider the safest way to do this without the coverslip breaking) to separate out the cells. Search on low power for longitudinal xylem vessels and then work up to high power to see detail. Biological drawings can then be made.

Learner Activity 2
Drawing Skills (OCR)
This is a short checklist for students to use when producing biological drawings e.g. of roots, stems and leaves to show the distribution of xylem and phloem for 3.1.3(b). The 8-point checklist also provides a quick way of marking student drawings. Simply give a tick or cross for each point and tot up the total out of 8. If the order of ticks and crosses corresponds to points 1-8, students can see what aspects they are doing well and where they are making mistakes. (For more guidance and good examples of biological drawings see the OCR Biological Drawing Skills Handbook).

Learner Activity 3
Race to the Top Activity
The standard material for demonstrating movement of a coloured dye up a plant stem is celery, but it does need to have a leafy top. As supermarkets cut off the leaves of the outer stems, the smaller middle stems are better. The advantage of celery is that if the stem is cut, the dyed vascular bundles are very clear and easy to see by eye and draw. To add interest, students could 'race' dyes up different plants, maybe by combining the celery practical with Rainbow Roses or Glow In the Dark Flowers. Another possibility is rhubarb stems (with leaf or part of leaf still attached), perhaps investigating how leaf surface area affects the rate of transpiration up the stem (*M4.1*). Razor blades can be used to cut thin transverse sections of the dyed celery stem to see the vascular bundles under the microscope, and these could then be compared with prepared stem slides with the xylem (lignin) coloured red with phloroglucinol (supporting module 1 and **PAG1**).

Learner Activity 4
Rainbow Roses Activity
Take white or cream long-stemmed roses, split the lower end of the stem longitudinally into four parts and snip off the lowest 1cm of each quarter of the stem to expose fresh xylem (unblocked by air bubbles or bacteria). Dip the quarters into four different conical flasks containing water coloured with four different food dyes, one per colour. A multi-coloured rose should be produced. A Google search of 'rainbow rose' will provide images to compare the class results with. YouTube 'how to' videos are also available to explain the process in more detail. This could also be tried with long-stemmed white chrysanthemums and carnations.

Learner Activity 5
How to Make Glowing Water (about.com)
http://chemistry.about.com/od/glowinthedarkprojects/a/glowingwater.htm

The link describes how to make a water-soluble fluorescent dye by cutting open a highlighter pen. This dissolved into water will glow under a black light (UV-A bulb). Fluorescein could also be used as it dissolves in aqueous solution. The idea of this activity is to make **Glow In the Dark Flowers**. Freshly cut stems of flowers are then placed in the fluorescent solution and left for the dye to ascend the xylem. Once the dye has reached the petals the class should test whether the flowers do indeed glow in the dark under the black light / UV-A source. Supermarket flowers that could be tried include white *Alstroemeria* and *Lisianthus*. There are synoptic links here to the use of the black light source (a Wood's Light) in diagnosing skin infections, the use of fluorescein in eye examinations, and also the use of fluorescent markers in molecular biology, e.g. DNA sequencing.

Learner Activity 6
How to Care for Fresh Cut Flowers (Teleflora)
http://www.teleflora.com/flowercare.asp

Students can be challenged to use their knowledge of transpiration to devise five rules for keeping cut flowers alive for as long as possible. Ideas can be found at this Teleflora website. Alternatively, they could explain the reasoning behind some of the rules, e.g. re-cutting stems, cutting stems at an angle, adding bleach to water, adding sugar to water, etc. This could be linked in with Valentine's Day to make it more relevant to students' interests.

Learner Activity 6
Collect Sap and Make Syrup (tapmytrees.com)
https://tapmytrees.com/collect-sap-make-syrup/

Students tend to take more interest in phloem when they learn that maple syrup is concentrated phloem sap. This website gives information about harvesting the sucrose-rich translocate from the phloem of sugar maples, including a selection of videos on this page. Ideally, provide a bottle of real maple syrup and let the class sample what phloem sap (concentrated by evaporation) tastes like (use disposable 'shot glasses' or plastic spoons).

Learner Activity 7
Birch Sap Syrup Activity and Lesson Plan (Mike Mitchell)
https://www.enr.gov.nt.ca/sites/enr/files/documents/birch_syrup_lesson.pdf

Following on from the last context, this lesson plan from Alaska gives full details for harvesting phloem sap from birch trees in the spring and converting it to syrup. To safeguard trees sterilised equipment (drill bit, taps) should be used, as in the instructions.

Learner Activity 8
Alaska Birch Syrup video (alaskabirchsyrup.com)
http://alaskabirchsyrup.com/about-alaskan-birch-syrup/alaska-birch-tree-syrup-water/

The 11.26 minute video on this website shows the whole process from phloem tapping to gourmet food production. The idea of the sustainability of this enterprise is mentioned, but students might like to weigh up the ecological impact of aspects such as transport to get people and materials to the remote sap collecting site, and the efficiency of energy use in purifying sucrose from a starting sap of low sucrose concentration (synoptic link to 6.3.2d).

Learner Activity 9
Surviving in the Desert (Survive Nature.com)
http://www.survivenature.com/desert.php

Students could be challenged to think about how they would use plants to obtain water in the desert. Apart from finding succulent plants such as cacti, which store water, covering leaves with plastic bags to collect transpired water is also a good technique, which could be tried in the lab or school grounds. This website outlines these ideas and how to make a solar water still obtaining the water from inside leaves (vegetation).

Learner Resource 1

The weirdness of plants

The focus of learning outcome 3.1.3(a) is how large size creates distances between cells and resources that are too large for diffusion, necessitating mass flow transport systems. This is a slightly different angle to the effect of surface area to volume ratio on exchange in section 3.1.1 but the two ideas are brought together on this sheet.

Discussion Points

This list of ideas about plant structure and physiology can be used as a springboard for class discussion. Selected statements could be presented orally or on a PowerPoint. Students could be asked to consider if they are true or false, to find evidence to support some or all of the statements and to vote on whether plants have a 'weird' way of maintaining life.

Task:

After considering these statements students could prepare a written summary, poster, PowerPoint or drama presentation on 'Why it is really WEIRD to be a plant'.

Features like the enormous size of some plants, the low proportion of living to dead tissue in trees, the spanning of two habitats, being stationary and undergoing marked seasonal changes in physiology (in temperate climates) could all be included and hopefully students will come up with more ideas for themselves.

Learner Resource 1

The weirdness of plants

Activity	True	False
Most of the volume in trees is dead xylem with only a thin cylinder of living tissue around the trunk and woody branches, so surface area to volume ratio doesn't matter.		
Plants grow bigger than animals so must have excellent transport systems.		
The lower metabolic rate of plants compared to animals allows a slower rate of transport.		
Plants have two transport systems but animals only have one.		
A contractile pump, like the heart for faster transport, is impossible in plants because plant cells have walls.		
Plants live in two different habitats at once, the roots in the soil (rich in water and ions, low in gases) and the leaves experiencing the opposite conditions in the air.		
Large surface area to volume ratio of the root hair system is crucial for the uptake of water and minerals (exchange).		
Large surface area to volume ratio of the leaves is crucial for carbon dioxide uptake and oxygen release (exchange).		
The same branching fractal pattern seen in roots below the ground and shoots above the ground to maximise surface area for exchange is seen in the bronchial tree of the lungs and in branching capillary networks.		
The surface area to volume ratio of the aerial plant parts has more effect on water loss (transpiration) than on obtaining raw materials.		
Surface area to volume ratio is important in some xerophytic adaptations.		
Plants make solid food (glucose) and building materials (wood) out of just a liquid (water) and a gas (carbon dioxide) that is present in only 0.04% of the air.		
Plants can't move around so have to manipulate other organisms into moving their gametes and seeds for them.		
Plants in the UK partially self-destruct and then sleep for half the year.		

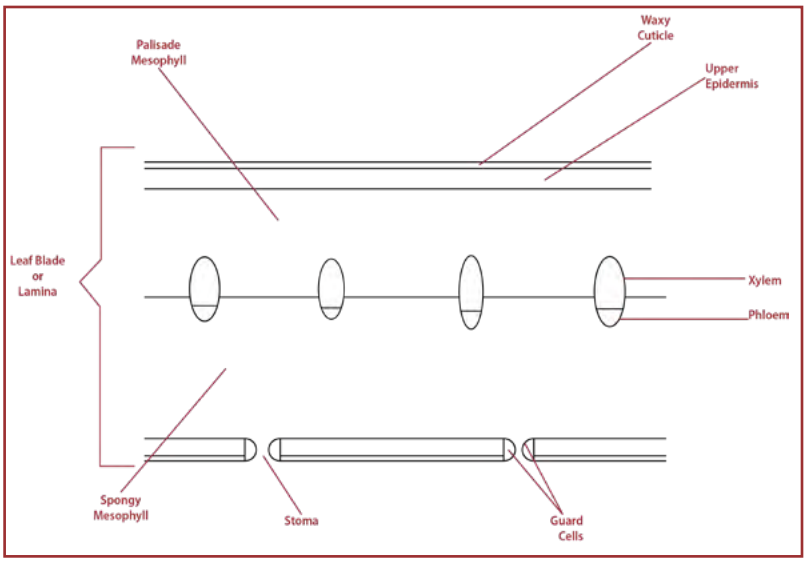
Learner Resource 2

Drawing Skills

1. Your drawing and its label lines must be done with a really sharp pencil (not a pen).
2. Your drawing should take up at least half the page / space.
3. Lines need to be clear and continuous – not ragged or broken – and no shading or colouring is allowed.
4. Rule the label lines (in pencil).
5. Make sure the label lines touch the part you are labelling.
6. Don't let the label lines cross each other.
7. Ensure the proportions are correct, i.e. different areas are the right size relative to each other, and that your drawing is a true likeness of the slide or biological specimen that you are drawing.
8. Label all the different areas of tissue that you have shown, writing the words in pencil or pen.

LOW POWER TISSUE PLAN

Rule: A low power tissue plan defines the extent of areas of different tissues but does NOT show any individual cells. For example, this is a low power tissue plan of the tissues in a transverse section of a leaf.



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