UNIT 4 Transport and Gas Exchange

Timing This unit comprises approximately 20% of the learning material in AS Biology, and about 10% of the learning material in a complete Biology A Level learning programme.

Recommended Prior Knowledge Knowledge of cell structure, as covered in Unit 1, will be helpful here, as will an understanding of diffusion, osmosis and active transport.

Context This Unit considers the way in which cells are provided with their requirements. It builds on what students know of cell structure and movement into and out of cells, and lays the foundations for further work on physiology at A2 level. The work on blood in this Unit leads into the topic of immunity in Unit 5.

Outline The topic of transport is introduced by considering why large organisms need transport systems. Plant transport, including the relation between the structure and function of transport tissues, is then dealt with. Transport in mammals, including structure and function of the heart, blood vessels and blood, are considered, which leads into gas exchange in humans. If preferred, transport and gas exchange in mammals could be covered before transport in plants. There are good opportunities within this Unit for students to reinforce their practical skills relating to Assessment Objectives in Group C (Experimental skills and investigations), particularly in using the microscope to make observations and record them as drawings. Try to ensure that each student works alone and under time pressure on some occasions, as this will help to prepare for the practical examination(s).

Reinforcement and formative assessment < **Reinforcement and formative assessment** It is recommended that, towards the end of the time allocated to the unit, time be taken to permit reinforcement of the learning that has occurred. Small groups of two or three students could be encouraged to work together for an hour or two of lesson time, plus homework for a week or two. They should prepare a presentation of a topic to their peers. This could be in the form of a poster, a video, a PowerPoint presentation, an OHP illustrated talk…

Formative assessment could take the form of student self-marked minitests, taking just 10 or 15 minutes for students to do and then mark for themselves, perhaps using questions from online question banks such as http://www.learncie.org.uk/ or http://exam.net/public/misc/pub_home.asp – discussing the correct answers as a whole class. At the end of the unit, there should be a much larger formative assessment test, using appropriate past-examination and similar style questions, taking a lesson to do, and a lesson to provide feedback after marking by the teacher.

	Learning Outcomes	Suggested Teaching Activities	Online Resources	Other resources
G(a)	explain the need for transport systems in multicellular plants and animals in terms of size and surface area to volume ratio **Learning activities** – use cubes and questions with diagrams to build understanding of: the relationship between surface area and volume; the distance from the outside to the inside; for smaller and larger shapes, and for long-thin, flat and cuboidal / spherical shapes – examine a circus of different organisms macroscopically and microscopically for features of their transport, gas and nutrient / waste exchange systems – using whole fresh and preserved specimens, microscope slides, photomicrographs and the CIE Bioscope	Use small cubes to build 'organisms'. Students can build cubic organisms with different numbers of blocks, and calculate surface area to volume ratios to discover how this ratio decreases as volume increases. They can also build organisms using the same number of blocks (i.e. the same volume) of different shapes, to illustrate how flattened organisms have larger surface area to volume ratios than 'cubic' ones. Discuss how this relates to the need for transport systems for gases, as well as nutrients and other substances, in animals. Discuss the way in which the branching shape of plants brings a very large surface area into contact with air, so there is no need for a transport system for gases. However, water must be transported from roots to leaves, and nutrients from sources to sinks.	CIE Bioscope http://teachers.net/lessons/posts/2518.html protocol for surface area: volume investigation http://employees.csbsju.edu/ssaupe/biol116/surf-vol-ratio.htm series of exercises on surface area: volume ratio	Gelatine, or better agar, blocks can be coloured using a pH indicator such as cresol red or phenolphthalein. When dropped into hydrochloric acid, the blocks change colour. Blocks can be cut to represent 'cubic' organism and the effect of surface area to volume ratio on diffusion may be measured. There is a protocol in *Advanced Biology principles and applications. Study Guide* Clegg and Mackean *Biofactsheet 7: Comparing transport in plants and animals.* *Biofactsheet 81: Gas exchange in plants* *Biology*, Jones, Fosbery , Taylor and Gregory and other textbooks include this topic

	Learning Outcomes	Suggested Teaching Activities	Online Resources	Other resources
G(d)	describe the distribution of xylem and phloem tissue in roots, stems and leaves of dicotyledonous plants **Learning activities** use dye (e.g. eosin) and whole small plants to investigate water transport system use microscopes, CIE Bioscope and photomicrographs to investigate distribution of xylem and phloem in roots, stems and leaves of dicotyledonous plants such as *Ranunculus* and *Ligustrum* investigate and calculate the sizes of structures in xylem and phloem, and magnification of images using microscope slides and CIE Bioscope	Students can stand small plants with intact root systems (wash soil off first) in dye such as eosin for 10-30 minutes, then cut thin sections by hand to investigate the distribution of the dye; this shows the position of xylem vessels in all parts of the plant, and also emphasises their continuous nature. They will probably already have drawn a TS of a leaf in Unit 1, so this can be quickly revised now. Prepared slides of TS root and TS stem provide opportunities for further developing skills of observation and recording, as well as calculating magnification.	http://images.botany.org/ Hundreds of high-quality images, including many leaf, stem and root micrographs. CIE Bioscope Lots of University Department and microscope manufacturer websites have wide collections of photomicrographs that students will find interesting e.g. http://micro.magnet.fsu.edu/index.html	Both *Practical Advanced Biology*, King et al, and *Comprehensive Practical Biology*, Siddiqui, have guidance for observing and recording the distribution of these tissues. The CD-ROM: *Images of Biology for Advanced Level* published by Stanley Thornes has suitable images that are useful here *Biofactsheet 19: Plant tissues* *Biology*, Jones, Fosbery , Taylor and Gregory and other textbooks include this topic

	Learning Outcomes	Suggested Teaching Activities	Online Resources	Other resources
G(g)(h)	explain the movement of water between plant cells and between them and their environment, in terms of water potential; describe the pathways and explain the mechanisms by which water is transported from soil to xylem and from roots to leaves **Learning activities** – review water potential with oral question and answer / whole class discussion and revision questions – work out which way water will flow to and from cells / environments with given water potentials (no calculations of water potential are expected) – build understanding of mechanisms and pathways of movement of water through plants with oral question and answer / whole class discussion and written questions – give brief written explanation why water flows as a result of water potential, and the flow of water from soil, through plant, to air as a result of water potential (including the role of cohesion-tension), and other potential and actual mechanisms of water flow	Use questioning to revise earlier work on osmosis, and lead in to the way in which root hairs provide a large surface area for water uptake. Root hairs can be seen clearly on newly-germinated seedlings, such as mung beans, if these are grown on damp filter paper or cotton wool. Provide an overview of the movement of water down a water potential gradient from soil to air, before looking at each part of this pathway in more detail. The work on cohesion-tension needs to be linked to the next section (G(b)(c)) on transpiration. Transpiration reduces the water potential at the top of the plant, producing the 'tension'.	http://www.microscopy-uk.org.uk/mag/artmar00/watermvt.html A clear description of water movement through a plant, including high-quality micrographs. http://web.ukonline.co.uk/webwise/spinneret/plants/pltrsu.htm interactive questions and answers (hold mouse over answer to reveal) http://www.mhhe.com/biosci/pae/botany/histology/html/memtrans.htm nice description of symplast and apoplast http://users.rcn.com/jkimball.ma.ultranet/BiologyPages/X/Xylem.html detailed information on transport across roots and up xylem	**BIOFACTSHEET 82: TRANSPORT IN FLOWERING PLANTS** *Biofactsheet 108: Water movement across the root.* *Biology*, Jones, Fosbery , Taylor and Gregory and other textbooks include this topic

	(root pressure and capillarity) – research in books and on the web, the various pathways by which water can flow across the root (apoplast, symplast and vacuolar) and the role of the endodermis and casparian strip, giving a brief written / diagrammatic summary of your findings			

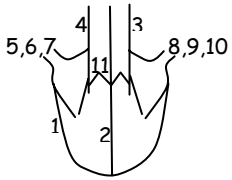
	Learning Outcomes	Suggested Teaching Activities	Online Resources	Other resources
G(b) (c)	define the term *transpiration* and explain that it is an inevitable consequence of gas exchange in plants; describe how to investigate experimentally the factors that affect transpiration rate **Learning activities** – review and build understanding of transpiration with oral question and answer / whole class discussion and written questions – give a brief written explanation of transpiration, explain why it is inevitable, and what use is made of it – use a potometer to investigate the effect of wind speed on rate of transpiration – plan and carry out a controlled investigation into the effect of temperature on rate of transpiration – plan and / or carry out similar investigations into the effect of humidity and / or light on rate of transpiration	Use questioning to help students to revise what they remember from earlier courses about transpiration. Discuss how water changes state from liquid to vapour inside the leaf, and then diffuses down a water potential gradient through open stomata into the surrounding air. This needs to be linked to cohesion-tension the previous section (G(g)(h)), in which the loss of water from the leaf reduces hydrostatic pressure at the top of xylem vessels, thus providing the pressure gradient which ensures mass flow of water up these vessels. A simple potometer can be made using a long piece of capillary tubing to which a short length of rubber tubing is attached at one end. Submerge it all in water and shake gently until water completely fills it. Make a slanting cut across a leafy shoot, and - still under water - push this tightly into the rubber tubing. Support the whole apparatus vertically and record the height of the air/water meniscus at suitable time intervals. If you have access to data-logging equipment and a humidity-recording sensor, you could try enclosing part of a plant inside a plastic bag and recording the increase in humidity as transpiration takes place.	http://users.rcn.com/jkimball.ma.ultranet/BiologyPages/T/Transpiration.html information and links to related topics http://www.geog.ouc.bc.ca/physgeog/contents/8i.html clear explanation of the relationship between evaporation and transpiration http://cas.bellarmine.edu/tietjen/Laboratories/Transpiration/transpiration_text.htm has a simulation program that allows you to investigate the effect on transpiration of changing various parameters	Both *Practical Advanced Biology*, King et al, and *Comprehensive Practical Biology*, Siddiqui have protocols for investigations relating to transpiration. Students need reminding that potometers measure rates of water uptake. If a potometer is placed on a balance sensitive to small changes in mass, then it is possible to measure water uptake *and* transpiration. *Biofactsheet 64: Transpiration* *Biology*, Jones, Fosbery , Taylor and Gregory and other textbooks include this topic

	Learning Outcomes	Suggested Teaching Activities	Online Resources	Other resources
G(e) and (f)	describe the structure of xylem vessel elements ; relate the structure of xylem vessel elements to their functions **Learning activities** – use photomicrographs, the CIE Bioscope, microscope slides, electron micrographs and diagrams from books and the web to build understanding of the structure of xylem vessels – build understanding of the relationship between xylem vessel structure and function with oral question and answer / whole class discussion and brief written questions	Photomicrographs and diagrams can be used to illustrate the structure of xylem vessels. Discuss with students how their structure, including the lignified walls, is related to water transport and also to their function in support. Make clear that xylem *tissue* contains several different types of cells, not just vessel elements.	http://images.botany.org/ Photomicrographs of xylem. CIE Bioscope Lots of University Department and microscope manufacturer websites have wide collections of photomicrographs that students will find interesting e.g. http://micro.magnet.fsu.edu/index.html	The CD-ROM: *Images of Biology for Advanced Level* published by Stanley Thornes has suitable images that are useful here *Biology*, Jones, Fosbery , Taylor and Gregory and other textbooks include this topic

	Learning Outcomes	Suggested Teaching Activities	Online Resources	Other resources
G(i)	describe how the leaves of xerophytic plants are adapted to reduce water loss by transpiration **Learning activities** circus of living examples of xerophytes, photographs, diagrams, photomicrographs, CIE Bioscope, microscope slides of specimens, electron micrographs from which to make guided observations and annotated diagrams	Show students living examples of xerophytes, and discuss with them the ways in which plants can reduce their water loss. Ask them to interpret diagrams, photographs and living examples of leaves, describing specific features which help them to reduce water loss.	http://www.cix.co.uk/~argus/ in A2 module 6, section 15.1 is a slide show and information about xerophytes in different habitats.	*Biofactsheet 29: Plant and animal adaptations to dry habitats.* *Biofactsheet 84: Xerophytes and hydrophytes* *Biology*, Jones, Fosbery , Taylor and Gregory and other textbooks include this topic

	Learning Outcomes	Suggested Teaching Activities	Online Resources	Other resources
G(e) and (f)	describe the structure of sieve tube elements and companion cells and be able to recognise these using the light microscope ; relate the structure of sieve tube elements and companion cells to their functions **Learning activities** – use photomicrographs, the CIE Bioscope, microscope slides, electron micrographs and diagrams from books and the web to build understanding of the structure of phloem sieve tube elements and companion cells – build understanding of the relationship between structure of phloem sieve tube elements and companion cells and their functions with oral question and answer / whole class discussion and brief written questions	Use photomicrographs and diagrams to illustrate the structure of phloem sieve tube elements and companion cells. Note that it is now believed that the protein strands are not present in living, functioning phloem tissue. Describe translocation to the students by explaining that sucrose is actively loaded into phloem at the source, and then removed at the sink. At the source, this draws extra water into the phloem by osmosis, so increasing the hydrostatic pressure. Fluid therefore moves along the phloem from source to sink by mass flow, down this hydrostatic pressure gradient. (Other theories have been largely discounted, and students do not need to consider these.)	Google, images, phloem links to a number of useful illustrations http://anubis.ru.ac.za/Presentations/Anatomy/Phloem_%202001.pdf nice presentation, with good illustrations, but needs broadband http://www.science.siu.edu/plant-biology/PLB320/Lect_F03/Lect4.pdf detailed information about mechanisms of phloem transport including some useful illustrations	*Practical Advanced Biology*, King et al, and *Comprehensive Practical Biology*, Siddiqui, both have a protocol for investigating the rate of translocation of sucrose in a potato stolon. The CD-ROM: *Images of Biology for Advanced Level* published by Stanley Thornes has suitable images that are useful here *Biology*, Jones, Fosbery , Taylor and Gregory and other textbooks include this topic

	Learning Outcomes	Suggested Teaching Activities	Online Resources	Other resources
G(t)	describe the mammalian circulatory system as a closed double circulation **Learning activities** very briefly contrast with organisms organised differently – open circulation of insect, single of fish, double with 3 hearts if squid, leading to understanding of the terms 'closed' and 'double' in context of circulatory system, demonstrated in brief written explanations of these two terms	Introduce the topic of transport in mammals with an overview of the whole circulatory system; students should remember this from earlier courses.	http://www.nzoomwebchallenge.co.nz/site/2002winners/westlake/closed.htm nice explanation of closed double circulatory system Diagrams of insect, fish and squid found using search engines such as google, dogpile or copernic on the web	*Biology*, Jones, Fosbery , Taylor and Gregory and other textbooks include this topic

	Learning Outcomes	Suggested Teaching Activities	Online Resources	Other resources
G(r) (s)	describe the external and internal structure of the mammalian heart **Learning activities** – reinforce learning and labelling of heart diagrams by practising the drawing of a very simple diagram as below (numbers indicate order of drawing lines), modifying it to show accurate blood vessel pathways, thickness of muscle walls, tendinous cords and papillary muscles, sinoatrial node, atrioventricular node and bundle of His / Purkyne tissue  – dissect a heart if this is possible, or see one being dissected (this activity is not essential to this course, but provides the best understanding of heart structure and the nature of animal tissues – hearts are part of the food chain, and therefore may be considered by some to be more suitable dissection material than small mammals whose only reason for existence is to be killed for dissection)	Use diagrams to discuss this topic. If possible, demonstrate the structure of an animal heart obtained from a butcher - although such hearts often have lost most of their atria. Relate the difference in thickness of the left and right ventricle walls to the higher pressure needed in the systemic than in the pulmonary circulation.	http://www.bbc.co.uk/dna/h2g2/A494200 A simple, clear description of heart structure and function. http://web.ukonline.co.uk/webwise/spinneret/circuln/heart.htm interactive questions on the heart and circulation (hold the mouse over the answer to reveal) Google, images, mammalian heart produces a number of useful images	*Practical Advanced Biology*, King et al, and *Comprehensive Practical Biology*, Siddiqui, and *Advanced Biology principles and applications. Study Guide* Clegg and Mackean all have protocols for dissecting a heart and investigating its function. *Biofactsheet 35: Structure and function of the mammalian heart* *Biology*, Jones, Fosbery , Taylor and Gregory and other textbooks include this topic

	Learning Outcomes	Suggested Teaching Activities	Online Resources	Other resources
G(u)	describe the cardiac cycle **Learning activities** – use the diagram learned in G(r)(s) to build understanding of the cardiac cycle by drawing diagrams taking the heart through the whole cardiac cycle, showing the contraction and relaxation of muscle, and status of valves in the middle of diastole, atrial systole and ventricular systole – use whole class discussion / oral question and answer based around the OHP overlays to build understanding of pressure and volume changes within the heart and how these relate to muscle contraction and relaxation and valve opening and closing – make your own summary graph showing the pressure and volume changes on one side of the heart, and annotated with the time each valve opens and shuts, and the evidence that can be seen on the graph that this is so	If available, use animations to support understanding here. Ensure that students realise that both sides of the heart contract and relax in unison. They should understand that valves do not actively open and close, but are pushed open and shut by differences in pressure on either side. Use OHP overlays to gradually build up graphs showing pressure changes in atria, ventricles and arteries during the cardiac cycle. Provide questions to help students to practise interpreting these graphs.	http://web.ukonline.co.uk/webwise/spinneret/circuln/heart.htm click on the button with a ? to display a simple animation showing the sequence of diastole and systole in atria and ventricles. http://learningat.ke7.org.uk/scienceweb/alevel/biology/AS%20Interactive/e-a-level/10/10.8.htm lots of nice cardiac resources, including animations (require quicktime)	*Biology*, Jones, Fosbery , Taylor and Gregory and other textbooks include this topic

	Learning Outcomes	Suggested Teaching Activities	Online Resources	Other resources
G(v)	explain how heart action is initiated and controlled (reference should be made to the sinoatrial node, the atrioventricular node and the Purkyne tissue) **Learning activities** – whole class discussion / oral question and answer, plus diagrammatic and written questions to build understanding of the initiation of heart beat, and integration of the contraction of the atria and ventricles – use the diagram learned in G(r)(s) to reinforce the understanding by drawing a series of diagrams to show initiation of heartbeat, atrial systole, delay by the atrioventricular node and finally ventricular systole	Students firstly need to be clear that the heart is myogenic (i.e. it does not need to receive nerve impulses from outside to initiate heart beat) They need to understand the role of the sinoatrial node as pacemaker initiating muscle cell depolarisation and contraction; the network of cardiac muscle fibres within the atria and the ventricles in passing the wave depolarisation and contraction; the ring of connective tissue between the atria and ventricles insulating them; the atrioventricular node in delaying the passage of depolarisation to the ventricles so that the atria can contract first; the Purkyne tissue is passing the depolarisation down to the bottom of the ventricles so they depolarise and contract bottom-up, squeezing the blood out up the arteries	http://hyperphysics.phy-astr.gsu.edu/hbase/biology/sanode.html clear illustration of sinoatrial node and atrioventricular node http://learningat.ke7.org.uk/scienceweb/alevel/biology/AS%20Interactive/e-a-level/10/10.8.htm lots of nice cardiac resources, including some material about initiation of heartbeat	*Biology*, Jones, Fosbery , Taylor and Gregory and other textbooks include this topic

	Learning Outcomes	Suggested Teaching Activities	Online Resources	Other resources
G(?)	Arteries, veins and capillaries **Learning activities** – enhance understanding of structure and relation to function by whole class discussion / oral question and answer / annotation of provided diagrams – use microscope slides, CIE Bioscope, photomicrographs and (for capillary) electron micrographs to observe, draw and explain the relationship between structure and function through annotations and bullet points	Students are likely to know the basic structure of arteries and veins and capillaries, so the aim here is to raise the level of their understanding to AS level (naming the layers in the walls, relating structure to function) and observing and drawing prepared TS slides using a microscope, thus developing their observing and drawing skills. They could practise measurement using a graticule.	http://sln.fi.edu/biosci/vessels/vessels.html some materials to interest students, including movies. http://www.goerie.com/nie/itsaboutlife/exploring_vessels.html information on exploring vessels	*Biology*, Jones, Fosbery , Taylor and Gregory and other textbooks include this topic

	Learning Outcomes	Suggested Teaching Activities	Online Resources	Other resources
G(n)	describe the structure of red blood cells, phagocytes and lymphocytes and explain the differences between blood, tissue fluid and lymph **Learning activities** – examine red blood cells under the light microscope, in photomicrographs, with the CIE Bioscope and in electron micrographs, and compare them to other cells such as white blood cells – brief written explanation of how the structural features of red blood cells are elated to their function – whole class discussion / verbal question and answer and written questions about how tissue fluid and lymph are formed from blood, their functions, and thus the differences that are found between them	Once again, students are likely to have basic knowledge of this topic already. It is suggested that at this stage you do not elaborate on the different types of white cells; these are dealt with in Unit 5. Use this topic to revise cell structure by asking students to explain how red cells are specialised for their function of oxygen transport.	Google, images, blood cells reveals some interesting illustrations http://education.vetmed.vt.edu/Curriculum/VM8054/Labs/Lab6/Lab6.htm Nice material including photomicrographs (uses term granulocyte for phagocyte) CIE Bioscope Lots of University Department and microscope manufacturer websites have wide collections of photomicrographs that students will find interesting e.g. http://micro.magnet.fsu.edu/index.html	*Practical Advanced Biology*, King et al, and *Comprehensive Practical Biology*, Siddiqui, both include practical work looking at blood cells. The latter text contains several good micrographs, in colour. *Biofactsheet 36: Structure and function of blood and lymph* *Biofactsheet 62: Animal tissues I – epithelia and blood* *Biofactsheet 89: Tissue fluid* *Biology*, Jones, Fosbery , Taylor and Gregory and other textbooks include this topic

	Learning Outcomes	Suggested Teaching Activities	Online Resources	Other resources
G(o)(p)	describe the role of haemoglobin in carrying oxygen and carbon dioxide; describe and explain the significance of the dissociation curves of adult oxyhaemoglobin at different carbon dioxide levels (the Bohr effect) **Learning activities** – step by step introduction through whole class discussion / verbal question and answer / animations and simulations / answering written questions / making annotations to diagrams: o to introduce partial pressure as a measure of amount of oxygen o to introduce the oxygen dissociation curve as results from experimental measurements o to explain the loading and unloading of oxygen in lung and in resting tissue o to explain the release of more 'stored' oxygen as a result of the lower partial pressure of oxygen in working tissue o to explain the roles of haemoglobin in carriage of carbon dioxide in buffering	Use question and answer to help students to remember what they have already learnt about haemoglobin structure, then move on to discuss with them how a haemoglobin molecule carries oxygen. Emphasise the importance of releasing oxygen, as well as binding with it. Introduce the oxygen dissociation curve steadily and carefully - students often find this difficult to understand. Give them questions to answer which involve interpretation of the curve, to help them to consolidate their understanding and to develop their skills of data handling. The Bohr shift makes sense if you explain it in relation to carbon dioxide carriage by haemoglobin. Its significance should be discussed in relation to the greater need of tissues for oxygen when respiring actively.	http://www.manbit.com/hbdiss.htm An interactive haemoglobin dissociation curve; students can alter parameters such as carbon dioxide concentration and see how this affects the curve. http://www.biology4all.com/resources_library/details.asp?ResourceID=8 A downloadable PowerPoint presentation.	*Biology*, Jones, Fosbery, Taylor and Gregory. explains the oxygen dissociation curve and has structured questions (with answers) about it. *Biofactsheet 9: Oxygen dissociation curves.*

	hydrogen ions, (and, less importantly, in forming carbamino compounds) o to relate the effect of CO_2 on haemoglobin to the Bohr effect, facilitating the unloading of oxygen from 'store' in haemoglobin in working tissues			

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G(q)	describe and explain the significance of the increase in the red blood cell count of humans at high altitude **Learning activities** – Bibliographic and web-based research leading to a brief written / diagrammatic summary of the key points	Students may be interested to relate this to the benefits to athletes of training at high altitude.	http://www.sportsci.org/traintech/altitude/wgh.html A good article on altitude training and changes in blood cell counts, including data and references.	*Biology*, Jones, Fosbery , Taylor and Gregory and other textbooks include this topic

	Learning Outcomes	Suggested Teaching Activities	Online Resources	Other resources
H(a)	describe the structure of the human gas exchange system, including the microscopic structure of the walls of the trachea, bronchioles and alveoli with their associated blood vessels **Learning activities** – examine and draw from microscope slides, CIE Bioscope, photomicrographs and electron micrographs from books and the web, trachea, bronchioles, capillaries (and arterioles & venules) and alveoli	Some of this will be revision for most students. Use question and answer to help them to remember what they know about this topic. Help them to raise their knowledge and understanding to AS level by providing prepared slides of TSs of trachea and bronchiole wall, and of lung tissue, for them to interpret and draw.	http://www.biology.eku.edu/RITCHISO/301notes6.htm useful notes and diagrams http://www.meddean.luc.edu/lumen/MedEd/Histo/frames/Histo15.html some very nice photomicrographs CIE Bioscope Lots of University Department and microscope manufacturer websites have wide collections of photomicrographs that students will find interesting e.g. http://micro.magnet.fsu.edu/index.html	*Practical Advanced Biology*, King et al, and *Comprehensive Practical Biology*, Siddiqui, both have protocols investigating these structures. The latter text also has several good micrographs, in colour. *Biology*, Jones, Fosbery , Taylor and Gregory and other textbooks include this topic

	Learning Outcomes	Suggested Teaching Activities	Online Resources	Other resources
H(b)	describe the distribution of cartilage, ciliated epithelium, goblet cells and smooth muscle in the trachea, bronchi and bronchioles; describe the functions of cartilage, cilia, goblet cells, smooth muscle and elastic fibres in the gas exchange system **Learning activities** individual bibliographic research, followed by whole class discussion of validity of information (the major text books may be found to contradict one-another) and then make tables summarising, as far as is possible the location of various key structural components of these tissues such as elastic fibres, cilia etc.	Draw together information on distribution from the previous activity, before discussing functions.	http://www.meddean.luc.edu/lumen/MedEd/Histo/frames/Histo15.html some very nice photomicrographs CIE Bioscope Lots of University Department and microscope manufacturer websites have wide collections of photomicrographs that students will find interesting e.g. http://micro.magnet.fsu.edu/index.html	The CD-ROM: *Images of Biology for Advanced Level* published by Stanley Thornes has suitable images that are useful here *Biology*, Jones, Fosbery , Taylor and Gregory and other textbooks include this topic

	Learning Outcomes	Suggested Teaching Activities	Online Resources	Other resources
H(d)	describe the process of gas exchange between air in the alveoli and the blood **Learning activities** – annotate diagrams with key features of the process such as mass transport of materials (e.g. ventilation of larger bronchioles, blood flow), diffusion in / out of alveoli / smaller bronchioles (fast) in air, maximising diffusion gradients across alveolar membrane, minimising diffusion distance from alveolar air to blood plasma and cells so that slow diffusion in liquid is not a problem	Students will already have covered this, but they can now relate their knowledge to diffusion across cell membranes, and to the roles of blood flow and ventilation in maintaining diffusion gradients for oxygen and carbon dioxide between the alveoli and blood.	http://science.nhmccd.edu/biol/respiratory/alveoli.htm series of photomicrographs and animation about alveolus / capillary gas exchange http://www.pdh-odp.co.uk/diffusion.htm information and illustration	*Biology*, Jones, Fosbery , Taylor and Gregory and other textbooks include this topic

	Learning Outcomes	Suggested Teaching Activities	Online Resources	Other resources
H(e)	explain the terms *tidal volume* and *vital capacity* **Learning activities** – measure vital capacity using a simple volume-measuring spirometer or a large empty plastic bag into which a complete breath is blown, and which is then sealed and pushed into a calibrated bucket to see how large a volume of trapped air it contains. – tidal volume should only be measured using a spirometer containing soda-lime to absorb CO_2 and charged before use with medical oxygen (to avoid potential danger of poisoning) – home-made spirometers are possible, using plastic tube at least 1.5 cm internal diameter, an oxygen-filled beaker loosely kept upside down over water, and a soda-lime CO_2 absorber	If you have a spirometer or suitable data-logging apparatus available, use this to allow students to measure their own tidal volumes and vital capacity. If not, provide data for them to analyse.	http://en.wikipedia.org/wiki/Vital_capacity straight forward summary	*Biology*, Jones, Fosbery, Taylor and Gregory. has spirometer data and questions (with answers) involving their interpretation.

	Learning Outcomes	Suggested Teaching Activities	Online Resources	Other resources
H(g)(h)	describe the effects of tar and carcinogens in tobacco smoke on the gas exchange system; describe the symptoms of emphysema, chronic bronchitis and lung cancer **Learning activities** – web and bibliographic research leading to a short piece (maximum 400 words) of writing covering all the topics in learning outcomes H(g)(h) above and H(j) below	The topic of carcinogens in tobacco smoke could be used to link back to DNA structure and think about how a change in it can affect cell function; and also to cell division and discuss how mutation could affect its control and thus allow cells to multiply uncontrollably. There is a wide range of material on these topics on the internet; students could collect, display and analyse data about a particular smoking-related disease of the gas exchange system and give a short presentation to the rest of the class.	http://www.ash.org.uk/html/factsheets/html/fact04.html - edn1 Fact sheet about the relationship between smoking and many cancers, not only lung cancer. http://www.lung.ca/diseases/emphysema.html A Canadian site with information about emphysema, including data and suggestions for teaching this topic.	*Biology*, Jones, Fosbery , Taylor and Gregory and other textbooks include this topic

	Learning Outcomes	Suggested Teaching Activities	Online Resources	Other resources
H(i) (j)	describe the effects of nicotine and carbon monoxide on the cardiovascular system with reference to atherosclerosis, coronary heart disease and strokes; discuss the problems of cardiovascular disease and the ways in which smoking may affect the risk of developing cardiovascular disease **Learning activities** – from bibliographic and web-based research make annotated diagrams or bullet-pointed notes on the causes and effects of atherosclerosis (thrombosis and aneurysm) and how these relate to coronary heart disease and strokes – whole class discussion / verbal question and answer to build understanding of the problems caused by cardiovascular disease	This topic should be related back to earlier work on the structure and function of the heart, and the carriage of oxygen by haemoglobin.	www.bhf.org.uk British Heart Foundation has information and statistics on heart disease and risk factors. www.americanheart.org The American Heart Association also has statistics that students can analyse and use in support of presentations to the rest of the group.	*Biology*, Jones, Fosbery , Taylor and Gregory and other textbooks include this topic

	Learning Outcomes	Suggested Teaching Activities	Online Resources	Other resources
H(i)	evaluate the epidemiological and experimental evidence linking cigarette smoking to disease and early death **Learning activities** – use information from a number of sources to make a brief bullet point summary of the available evidence, and a brief written evaluation of the strength of the experimental and epidemiological case that smoking is linked to disease and early death	This is another good opportunity for students to develop data-handling skills. They should understand the difference between demonstrating a link between two factors and demonstrating that one *causes* the other. A web search will provide a very wide range of data from many different countries.	http://www.parliament.the-stationery-office.co.uk/pa/cm199900/cmselect/cmhealth/27/9120907.htm historical review of development of epidemiological knowledge http://users.rcn.com/jkimball.ma.ultranet/BiologyPages/E/Epidemiology.html illustrated article about epidemiology, using smoking as an example	A summary of some of this evidence is given in *Biology*, Jones, Fosbery Taylor and Gregory. *Advanced Biology principles and applications. Study Guide* Clegg and Mackean also has ideas for students to research.