

# A2 Biology Syllabus 9700

## Unit 2: Regulation and Control

### Recommended Prior Knowledge

Students should have a good understanding of cell structure. They should understand the concept of water potential and have a good knowledge of transport mechanisms across membranes, including how active transport takes place. They should also know the structure of a cell surface membrane and the role of the various components.

### Context

This unit could either precede or follow Unit 1. It builds on material covered at AS level; especially Section A, Cell Structure, Section B, Biological Molecules, Section D, Cell Membranes and Transport and Section G, Transport.

### Outline

Excretion of nitrogenous wastes, the need for communication systems in multicellular organisms, the roles of the nervous and endocrine systems, and plant growth regulators and are discussed and described. The control of blood glucose concentration and water content (by the kidney) illustrates the concept of homeostasis.

#### N Regulation and Control

- The importance of homeostasis
- Excretion
- Control of water and metabolic wastes
- Nervous and hormonal communication
- Response to changes in the external environment
- Regulation of the internal environment
- Communication and control in flowering plants
- Plant growth regulators

There are four main topics in this unit, excretion (including the kidney), nervous coordination, chemical coordination and plant communication. Some teachers prefer to teach it in the syllabus order. Others like to begin with the nervous system as it may be more familiar and can lead to a more detailed consideration of nervous transmission. Practical work on reflex reactions makes the unit interesting to many and therefore easier to understand. Plant communication could be taught separately, e.g. after photosynthesis or Crop Plants (section T), but, having grasped the receptor, communication method and effector concept in humans, it may be worthwhile moving students straight to the same concepts in plants. Please evaluate these various approaches, and choose the sequence of topics that seems most appropriate.

Use the practical opportunities within this Unit to develop strategies to help prepare students for Paper 5. Students will need to develop their skills relating to Assessment Objectives in Group C (Experimental skills and investigations), including data analysis and the design and evaluation of their own investigations. Try to ensure that each student works alone and under time pressure on some occasions.

| AO | Learning outcomes  | Suggested Teaching activities   | Learning resources   |
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| N  | (a) discuss the importance of homeostasis in mammals and explain the principles of homeostasis in terms of receptors, effectors and negative feedback; | <p>Most students will have covered this topic in earlier studies. Ensure that they know and can use the term homeostasis. Ask students to suggest ideas as to what should be controlled, i.e. what different parameters should be kept at a set point? Students should be able to suggest temperature, blood glucose concentration, blood pH (carbon dioxide concentration), water balance (and water potential) and metabolic wastes. The discussion should lead to a definition of negative feedback and an understanding of receptors and effectors.</p> <p><b>Class activities</b></p> <ol style="list-style-type: none"> <li>1. Participate in class discussion to review knowledge of homeostasis.</li> <li>2. Write a full definition of homeostasis based on the following points: <ul style="list-style-type: none"> <li>• maintenance of, an internal / a cellular, environment</li> <li>• at a, constant level / set point / norm / normal level / stable level <i>or</i> within normal limits</li> <li>• despite, changes / fluctuations, in the internal or external environment</li> <li>• using negative feedback control mechanisms</li> <li>• so that cells can function efficiently</li> </ul> </li> <li>3. Research (text books or the web) a definition of <i>negative feedback</i> based on the following points: <ul style="list-style-type: none"> <li>• physiological processes or a changing external environment can cause a variation from the set point</li> <li>• a mechanism is required to act to bring the internal environment back to the set point (and not beyond this point – most systems attempt to at least have only small oscillations about the set point)</li> <li>• every example of negative feedback involves a receptor and effector and most involve a control centre</li> </ul> </li> <li>4. Using a named example, draw a flow chart to summarise homeostatic control and negative feedback, clearly showing the named receptor(s), effector(s) (and control centre, if present).</li> </ol> | <p><a href="http://www.nicksnowden.net/Other_pages/546_Control_Coordination_and_Homeostasis.pdf">http://www.nicksnowden.net/Other_pages/546_Control_Coordination_and_Homeostasis.pdf</a><br/>summary notes that match the learning outcomes in this unit</p> <p><a href="http://www.biologymad.com/master.html?http://www.biologymad.com/Homeostasis/Homeostasis.htm">http://www.biologymad.com/master.html?http://www.biologymad.com/Homeostasis/Homeostasis.htm</a><br/>a good summary with diagram.</p> <p><a href="http://www.biology-online.org/4/1_physiological_homeostasis.htm">http://www.biology-online.org/4/1_physiological_homeostasis.htm</a><br/>the first few pages are relevant</p> <p><a href="http://scienceaid.co.uk/biology/humans/homeostasis.html">http://scienceaid.co.uk/biology/humans/homeostasis.html</a><br/>revision from GCSE</p> <p><a href="http://science.jrank.org/pages/3365/Homeostasis.html">http://science.jrank.org/pages/3365/Homeostasis.html</a><br/>good explanations</p> <p><b>AS and A Level Biology</b> (Chapter 19, p. 258) covers this learning outcome.</p> <p><b>Bio Factsheet 28: Feedback control mechanisms</b><br/><b>Bio Factsheet 161: Negative Feedback Mechanisms</b><br/>Both factsheets contain more information than required, but there are good explanations and the sheets will be useful for later learning.</p> |

| AO | Learning outcomes  | Suggested Teaching activities   | Learning resources   |
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| N  | (b) define the term <i>excretion</i> and explain the importance of removing nitrogenous waste products and carbon dioxide from the body; | <p>Provide students with a definition of excretion, and ensure that they can distinguish between excretion and egestion. Help them to understand where the different types of nitrogenous waste come from and discuss the consequences if this waste was not excreted. It would help if students know that removal of the amino group occurs in deamination with the formation of highly toxic ammonia and a useful keto acid (chemical energy e.g. for respiration or conversion for energy storage), and that, in many terrestrial animals, the ammonia is immediately converted to urea. Students are not expected to write out equations for the above, only to understand the process sufficiently to understand how this is different to ammonification carried out by bacteria and fungi as described in the nitrogen cycle (AS). Here, deamination is one process that is included in the term ammonification that also involves breakdown of urea to ammonia and purines, etc.</p> <p>Review AS (Transport) to discuss carbon dioxide as a waste product and revisit respiration in cells.</p> <p><b>Class activities</b></p> <ol style="list-style-type: none"> <li>1. Write a definition of excretion and explain how this is different from egestion.</li> <li>2. Review understanding of nitrogen-containing waste by producing a 2-columned table, listing the different nitrogenous waste products and making brief notes on each one (e.g. source, converted to, involvement of liver, re-use of some parts )</li> <li>3. Write a summary of carbon dioxide as a waste product, including where and how this is made, and consequences if it is not removed.</li> </ol> | <p><a href="http://ex-anatomy.org/nitro.html">http://ex-anatomy.org/nitro.html</a><br/>a detailed account of nitrogenous waste</p> <p><a href="http://www.ilng.in/pdf/mtg_bio_final.pdf">http://www.ilng.in/pdf/mtg_bio_final.pdf</a><br/>this contains more than students require, but has interesting information about nitrogenous waste in other organisms for background reading</p> <p>Excretion is covered in <b>AS and A Level Biology</b> (Chapter 19, p. 259).</p> <p><b>Bio Factsheet 59: Excretion</b><br/>Part of this factsheet is relevant for this learning outcome. The rest is useful for later.</p> |

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| N  | (c) describe the gross structure of the kidney and the detailed structure of the nephron with the associated blood vessels (candidates are expected to be able to interpret the histology of the kidney, as seen in sections using the light microscope); | <p>Provide students with a whole kidney (e.g. from a sheep) and / or prepared slides of cortex and medulla in transverse and longitudinal section. Show them, on a whole kidney, what is meant by <i>transverse</i> and <i>longitudinal</i> sections. Prepared slides of rat kidney (e.g. available to purchase from CIE) held up to the light, show the shape of the entire kidney in LS or TS, and the areas of cortex and medulla are also clearly seen. It is possible for students to dissect the kidney. They should be able to trace renal artery, renal vein and ureter and follow the blood vessels into the cortex.</p> <p>Provide students with a diagram of nephron structure, including the associated blood vessels for class activity 2. Review AS knowledge of blood vessels and transport, referring also to the high blood pressure in the renal artery. Ensure that students know that the venous system does not begin immediately after the glomerulus, and that there is a dense capillary network serving the nephrons.</p> <p><b>Class activities</b></p> <ol style="list-style-type: none"> <li>1. Make annotated drawings of the external appearance of a kidney, a section through the kidney and, using prepared slides, the histology of the cortex and medulla (using reference books to help interpret what is seen).</li> <li>2. Use a diagram of a nephron to annotate it with the processes that occur in each region.</li> <li>3. Carry out a kidney dissection to identify the main areas of the kidney and its associated blood vessels.</li> </ol> | <p><a href="http://faculty.washington.edu/kepeter/119/images/kidney_sections.htm">http://faculty.washington.edu/kepeter/119/images/kidney_sections.htm</a><br/>sections of the kidney to support a dissection and a study of microscope slides of the cortex and medulla</p> <p><a href="http://library.med.utah.edu/WebPath/RENAHTML/RENALIDX.html">http://library.med.utah.edu/WebPath/RENAHTML/RENALIDX.html</a><br/>excellent resource for medical photographs</p> <p><a href="http://ex-anatomy.org/vert.html">http://ex-anatomy.org/vert.html</a><br/>very detailed account of kidney structure, good for interested students</p> <p><a href="http://www.cie.org.uk/profiles/teachers/orderpub">http://www.cie.org.uk/profiles/teachers/orderpub</a><br/>microscope slides only available to CIE registered centres (in the current catalogue)</p> <p>Kidney and nephron structure is covered in <b>AS and A Level Biology</b> (Chapter 19, pp. 259-260). The CD-ROM: <b>Images of Biology for Advanced Level</b>, pub. Nelson Thornes has suitable images.</p> <p><b>Comprehensive Practical Biology for A Level</b> contains an exercise looking at macroscopic and microscopic kidney structure, as does <b>Practical Advanced Biology</b>. <b>Bioscope</b> also has images of kidney sections.</p> <p><b>Bio Factsheet 1: The kidney: excretion and osmoregulation</b> (also for learning outcome (d))</p> |

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| N  | (d) explain the functioning of the kidney in the control of water by ADH (using water potential terminology) and in the excretion of metabolic wastes; | <p>Students will already know the importance of the kidney in the excretion of nitrogenous waste. Ask students: why is it important to control the water content of the blood? Use question and answer to draw out ideas, using what they know about water potential gradients and osmosis. Discuss how the structure of the nephron relates to its function, ensuring that students understand how ultrafiltration and reabsorption take place to form urine and how ADH is involved in the control of water. Reference to the principles of active transport, facilitated diffusion, water potential and osmosis from AS would be useful. A simple consideration of the principle of counter-current should be included.</p> <p><b>Class activities</b></p> <ol style="list-style-type: none"> <li>1. Produce a table naming the parts of the nephron, outlining the processes that occur in each and stating the transport mechanisms involved.</li> <li>2. Explain how sufficient pressure is present for ultrafiltration and annotate diagrams to explain how the structure of the Bowman's capsule and glomerulus allows the process to occur. Include details of the components present in glomerular filtrate.</li> <li>3. Make bullet point notes to describe selective reabsorption in the proximal convoluted tubule (PCT).</li> <li>4. Rearrange a set of statements of events occurring in the loop of Henlé to produce a sequential explanation of the way in which the loop produces a low water potential in the medulla, and how this allows water to move down a water potential gradient from the inside of the collecting duct into the tissue fluid and capillaries in the medulla.</li> <li>5. Describe the roles of the hypothalamus and posterior pituitary in the control of water, explaining how ADH acts on the cell surface membranes of the cells lining the distal convoluted tubule (DCT) and collecting duct (CD), increasing the reabsorption of water from the fluid in the nephron.</li> <li>6. Interpret data (table and / or graph) relating to concentrations of</li> </ol> | <p><a href="http://users.rcn.com/jkimball.ma.ultranet/BiologyPages/K/Kidney.html">http://users.rcn.com/jkimball.ma.ultranet/BiologyPages/K/Kidney.html</a> includes a table showing the composition of glomerular filtrate</p> <p><a href="http://www.biologyinmotion.com/nephron/index.html">www.biologyinmotion.com/nephron/index.html</a> a simplistic animation, which may be helpful to some students, showing how the loop of Henlé produces a high concentration of salts, and how this draws water from the collecting duct</p> <p>more detailed animations of structure and function:<br/> <a href="http://www.biologymad.com/resources/kidney.swf">http://www.biologymad.com/resources/kidney.swf</a><br/> and<br/> <a href="http://www.sumanasinc.com/webcontent/animations/content/kidney.html">http://www.sumanasinc.com/webcontent/animations/content/kidney.html</a></p> <p><b>AS and A Level Biology</b> (Chapter 19, pp. 260-269) gives a very descriptive and detailed explanation of ultrafiltration and reabsorption. Students should make notes of the main points</p> <p><b>Bio factsheet 1: The kidney: excretion and osmoregulation</b></p> <p><b>Bio Factsheet 59: Excretion</b></p> <p><b>Bio factsheet 150: Answering Exam Questions on the Kidney</b></p> |

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| <b>AO</b> | <b>Learning outcomes</b>   | <p>different substances in each part of the nephron.</p> <p>7. Produce a flow chart to show the negative feedback control of water in the blood.</p>   | <b>Learning resources</b>   |
| <b>N</b>  | <p>(e)<br/>outline the need for communication systems within mammals to respond to changes in the internal and external environment;</p> | <p><b>Suggested Teaching activities</b></p> <p>Discuss with the class the need for communication between different organs in a multicellular organism. Students should already be familiar with the endocrine and nervous systems, so use question and answer to remind them of what they know. Students should understand that the two systems are for control, coordination and internal communication, and that they can interrelate and affect each other. Review and build on the earlier work done on homeostasis. Check that they have written clear definitions to the terms in class activity 2.</p> <p><b>Class activities</b></p> <ol style="list-style-type: none"> <li>1. Participate in a class or group brainstorming session to suggest: examples of internal changes in organisms; examples of changes in external environment; how multicellular organisms are organised; features of the endocrine system; features of the nervous system. Presentation of ideas to the class if done in groups.</li> <li>2. Research and then give definitions (written if not already done) and examples of the following: stimulus, receptor, effector, control centre, response, negative feedback.</li> <li>3. Produce a table showing internal changes, which organs / systems affected, receptors, communication method, effector(s) and response.</li> <li>4. A similar table could be used to consider the external changes in environment and the receptors, communication method and effectors involved.</li> <li>5. Give outline comparisons of the nervous and endocrine systems.</li> </ol> | <p>websites listed in the following learning outcomes consolidate the knowledge and understanding required for learning outcome (e)</p> <p>There is a short section on this learning outcome in <b>AS and A Level Biology</b> (Chapter 19, p. 258).</p> |

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| N  | <p>(f) outline the role of sensory receptors in mammals in converting different forms of energy into nerve impulses;</p> <p>(g) describe the structure of a sensory neurone and a motor neurone and outline their functions in a reflex arc;</p> | <p>Review the meaning of the term <i>receptor</i> and explain that the different forms of energy arriving at the receptor all get converted into electrical energy of the nerve impulse. At this stage students need to know that a stimulus leads to an action potential being generated (details of the action potential are covered later). If the Pacinian corpuscle is used as an example, students will be introduced to sensory neurones and can move on to learning outcome (g). Students will probably be familiar with reflex arcs and the neurones involved in them. Point out that many reflex actions (e.g. the pupil reflex) involve the brain rather than the spinal cord. <i>Note: some teachers prefer to teach learning outcome (f) after dealing with action potentials (learning outcome h).</i></p> <p><b>Class activities</b></p> <ol style="list-style-type: none"> <li>1. List the different sensory receptors in humans and name the forms of energy received by each receptor.</li> <li>2. Carry out experiments to investigate touch, temperature and pain receptors in the skin.</li> <li>3. Try SAQ19.10 <b>AS and A Level Biology</b>, giving examples of reflexes and detailing stimulus, receptor, effector and response.</li> <li>4. Review own knowledge, and then in pairs compare knowledge of structure and function of reflex arcs and sensory and motor neurones. Finally, group work to correct any misunderstandings.</li> <li>5. Draw, label and annotate diagrams of the structure of sensory and motor neurones and compare these to electron micrographs. It may also be possible to make models of the two different neurones or a section through an axon with myelin sheath.</li> <li>6. Draw a reflex arc and annotate to show the function of the neurones. Give an example of a reflex using the spinal cord and one using the brain.</li> <li>7. Carry out experiments on reflex actions and reaction times.</li> <li>8. Look at slides of cross sections of the spinal cord to see motor neurone cell bodies.</li> </ol> | <p>‘neurones’, ‘neurone’ and ‘reflex arc’ (Google images) – lots of useful visual material</p> <p>background information for interested students:<br/> <a href="http://www2.estrellamountain.edu/faculty/farabe/biobk/BioBookNERV.html">http://www2.estrellamountain.edu/faculty/farabe/biobk/BioBookNERV.html</a><br/> <a href="http://users.rcn.com/jkimball.ma.ultranet/BiologyPages/N/Neurons.html">http://users.rcn.com/jkimball.ma.ultranet/BiologyPages/N/Neurons.html</a></p> <p>‘reflexlab’ (Google) reveals many sites with procedures for investigating human reflexes</p> <p><a href="http://www.sciencejoywagon.com/explrsci/meda/reflex.htm">http://www.sciencejoywagon.com/explrsci/meda/reflex.htm</a> and<br/> <a href="http://www.intelligencetest.com/reflex/index.htm">http://www.intelligencetest.com/reflex/index.htm</a><br/> testing reflexes and reaction times</p> <p><a href="http://faculty.washington.edu/chudler/twopt.html">http://faculty.washington.edu/chudler/twopt.html</a><br/> investigates touch, temperature and pain</p> <p><a href="http://www.sumanasinc.com/webcontent/anisamples/neurobiology/reflexarcs.html">http://www.sumanasinc.com/webcontent/anisamples/neurobiology/reflexarcs.html</a><br/> animation of reflex arcs</p> <p><b>AS and A Level Biology</b> (Chapter 19, pp. 276-278 and 282-284) has detail which is appropriate for the learning outcome.</p> <p><b>Practical Advanced Biology</b> has descriptions of experiments investigating receptors in the skin, human reflexes, and also reaction times.</p> <p><b>Bio Factsheet 58: Reflex action</b></p> |

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| N  | (h) describe and explain the transmission of an action potential in a myelinated neurone and its initiation from a resting potential (the importance of sodium and potassium ions in the impulse transmission should be emphasised); | <p>Students often find this topic difficult. It is important to take it steadily and not to risk confusing students by giving them more detail and complexity than is needed.</p> <p>It may be best to start this topic by asking students to consider the roles of impulses and the difference between an impulse and an action potential. Action potentials effectively act as 'boosters' to ensure the impulse travels the distance (there are no action potentials in short neurones as current flow is sufficient to ensure the impulse travels such a short distance).</p> <p>Build on AS knowledge of membrane transport proteins to explain the sodium-potassium pump and voltage-gated channels. Explain how a potential difference arises across a membrane. Discuss the idea of <i>relatively impermeable</i> and <i>relatively permeable</i>. Students should understand how a resting potential is maintained in a neurone and how depolarisation generates an action potential. Help them to relate these events to the different areas of a graph showing an action potential.</p> <p>If it is possible to project an animation to the class, students could see what occurs at each stage: membrane polarised (resting potential maintained); depolarisation (action potential); repolarisation (resting potential restored). Otherwise demonstrate to the class using a large drawing of a section of the membrane showing the outside and inside of the neurone. Use different coloured or labelled (circular) cards to represent Na<sup>+</sup> and K<sup>+</sup> ions and place these in their correct position either side of the membrane. Add the different types of protein channels (labelled or same colour as the ions, plus ion pumps clearly different). Model the resting potential, alter to show depolarisation/action potential and hence transmission of an impulse. Use verbal question and answer to prompt suggestions of permeability states to the different ions, sensitivity of voltage-gated channels, and state of membrane</p> | <p><a href="http://www.biology4all.com/resources_library/details.asp?ResourceID=40">http://www.biology4all.com/resources_library/details.asp?ResourceID=40</a><br/>a nerve impulse animation</p> <p><a href="http://www.biologymad.com/NervousSystem/neveimpulses.htm">http://www.biologymad.com/NervousSystem/neveimpulses.htm</a><br/>a very comprehensive review of the transmission of nerve impulses (sensory receptors are also covered)</p> <p><a href="http://outreach.mcb.harvard.edu/animations/actionpotential.swf">http://outreach.mcb.harvard.edu/animations/actionpotential.swf</a><br/>excellent animation and interactive exercise that promotes learning</p> <p><b>AS and A Level Biology</b> gives a good guide to the level of treatment required (Chapter 19, pp. 278-281).</p> |

(polarised etc.). Use a large cut-out arrow to show the direction of the impulse. Once students understand the basic concepts, discuss how  $\text{Na}^+$  entering the axon creates a positive charge and a flow of current set up in a local circuit between this and the negatively charged resting potential in the area ahead. Allow students to suggest how current flow changes membrane permeability to  $\text{Na}^+$  to cause self-propagation of the action potential, and how/why this is in one direction only. Model the return to the resting potential showing movement of  $\text{K}^+$  by diffusion. Discuss the two phases of the refractory period - the absolute refractory period (when the neurone cannot be stimulated to depolarise), followed by the relative refractory period (when only a high intensity stimulus can lead to further depolarisations).

#### **Class activities**

1. Revise terms: partially permeable, impermeable, permeable, ATP, active transport, protein channels, diffusion, facilitated diffusion.
2. Draw a diagram (e.g. draw a simple cylinder to show the outside and inside of the neurone) to show the maintenance of the resting potential in a neurone. Annotate to summarise  $\text{Na}^+$  and  $\text{K}^+$  transport and make bullet points to describe the different permeabilities of the membrane to  $\text{Na}^+$  and  $\text{K}^+$  ions.
3. State the difference between an impulse and an action potential
4. Annotate an action potential graph with the sequence of events that occur.
5. Explain what occurs during the *refractory period* (time taken for return to resting potential).
6. Explain the difference between the following pairs of terms:
  - absolute refractory period and relative refractory period
  - resting potential and action potential
  - polarised and depolarised

| AO | Learning outcomes  | Suggested Teaching activities  | Learning resources  |
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| N  | (i) explain the importance of the myelin sheath (saltatory conduction) and the refractory period in determining the speed of nerve impulse transmission; | <p>Ask candidates to interpret diagrams and electron micrographs of an axon with a myelin sheath. They should know about Schwann cells and nodes of Ranvier, and be able to explain how saltatory conduction is brought about, as well as the very great effect that this has on speed of transmission of impulses. Students could</p> <p><b>Class activities</b></p> <ol style="list-style-type: none"> <li>Using Fig. 19.37 from <b>AS and A Level Biology</b> (or other suitable), produce a comparison table of diameter or unmyelinated and myelinated axon and conduction speed, interpreting the data.</li> <li>Draw a labelled, annotated diagram (e.g. Fig. 19.36 from <b>AS and A Level Biology</b>) to show transmission of an action potential in a myelinated axon. Include the terms <i>local circuit</i> and <i>saltatory conduction</i> and explain how transmission is increased in myelinated compared to unmyelinated axons.</li> <li>Using knowledge of the transmission of an action potential, explain how the refractory period will affect the speed of nerve impulse transmission.</li> <li>Study electron micrographs of unmyelinated and myelinated axons and make comparisons with own observations using light microscopes.</li> <li>Use prepared microscope slides to make drawings of a transverse section of nerve (helpful for microscopy skills and also helps to understand (i) the difference between a nerve and a neurone, and (ii) that not all axons are myelinated).</li> </ol> | <p><a href="http://www.bu.edu/histology/m/t_electr.htm">http://www.bu.edu/histology/m/t_electr.htm</a><br/>excellent histology images, for example:<br/><a href="http://www.bu.edu/histology/p/21201loa.htm">http://www.bu.edu/histology/p/21201loa.htm</a><br/>myelinated and unmyelinated axons</p> <p><a href="http://www.uni-mainz.de/FB/Medizin/Anatomie/workshop/EM/EMSchwannE.html">http://www.uni-mainz.de/FB/Medizin/Anatomie/workshop/EM/EMSchwannE.html</a><br/>many electron micrographs of myelinated (with nodes of Ranvier) and unmyelinated axons</p> <p><b>AS and A Level Biology</b> has a short but relevant section on this topic (Chapter 19, pp. 281-282).</p> <p><b>Comprehensive Practical Biology for A Level</b> and <b>Practical Advanced Biology</b> both contain a practical exercise recording and interpreting micrographs of nerve tissue.<br/><b>Bioscope</b> has images of nerves (LS and TS)</p> |

| AO | Learning outcomes  | Suggested Teaching activities   | Learning resources  |
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| N  | (j) describe the structure of a cholinergic synapse and explain how it functions (reference should be made to the role of calcium ions); | <p>Give students a definition of a <i>synapse</i> and explain that they will only be studying in detail a chemical synapse known as a cholinergic synapse. Make students aware that there are other types of chemical synapses, but do not go into detail. As they have already gained an understanding of ion channels, this is a topic where moving straight to class activities and summarising with a class discussion or short test may well be sufficient. In preparing class activity 2, ensure that each statement in the sequence has enough of a clue to allow students to work out the next step. Remind students of links with AS: for example, mitochondria, exocytosis, diffusion, membrane proteins, hydrolysis catalysed by enzymes. Students usually find interesting a class discussion about the effects of drugs on the transmission across the synapse.</p> <p><b>Class activities</b></p> <ol style="list-style-type: none"> <li>1. Draw and label a diagram of a synapse.</li> <li>2. Sequence a set of statements detailing the events that occur in synaptic transmission.</li> <li>3. Re-arrange a set of diagrams to arrive at the correct sequence of events in synaptic transmission.</li> <li>3. Having completed activity 2 and 3, add annotations to the sequenced diagrams (or draw own sequence of diagrams) and make additional bullet points to describe synaptic transmission.</li> <li>4. Observe electron micrographs of synapses and compare them with diagrams of a synapse.</li> <li>5. In small groups, verbally review the sequence of events in synaptic transmission, the student making the first statement choosing the next student to describe the next event, and so on or in pairs, one student chooses a diagram in the sequence and the other student should describe what is occurring and what will happen next.</li> <li>6. Linking back to AS and respiration (A2), explain why there are many mitochondria present.</li> </ol> | <p>A web search for 'synapse' and 'synapse electron micrographs' produces many superb diagrams and images</p> <p><a href="http://www.tvdsb.on.ca/westmin/science/sbioac/homeo/synapse.htm">http://www.tvdsb.on.ca/westmin/science/sbioac/homeo/synapse.htm</a><br/>a simple animation of synaptic transmission.</p> <p><a href="http://bcs.whfreeman.com/thelifewire/content/chp44/4403s.swf">http://bcs.whfreeman.com/thelifewire/content/chp44/4403s.swf</a><br/>a relevant animation, at the right level</p> <p><a href="http://www.sumanasinc.com/webcontent/animations/content/synaptictransmission.html">http://www.sumanasinc.com/webcontent/animations/content/synaptictransmission.html</a><br/>another good animation</p> <p><a href="http://users.rcn.com/jkimball.ma.ultranet/BiologyPages/D/Drugs.html">http://users.rcn.com/jkimball.ma.ultranet/BiologyPages/D/Drugs.html</a><br/>information about the effects of drugs of abuse on the nervous system</p> <p>An annotated diagram in <b>AS and A Level Biology</b> describes the structure and function of a cholinergic synapse ((Chapter 19, pp. 285-287). This text also gives brief descriptions of the actions of some drugs and toxins at synapses, which may interest students.</p> <p><b>Bio Factsheet 20:</b> <i>Nerves and synapses</i></p> <p><b>Bio Factsheet 155:</b> <i>Answering exam questions on neurones and synapse</i></p> |

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### Learning outcomes

(k)  
outline the roles of synapses in the nervous system in determining the direction of nerve impulse transmission and in allowing the interconnection of nerve pathways;

### Suggested Teaching activities

Begin with a revision of synaptic transmission, asking students to consider which aspects ensure that the transmission of impulses only occurs in one direction across a synapse. Students should get the idea that the transmitter substance is in vesicles that are only found in the presynaptic neurone and that, when the transmitter is released into the synaptic cleft, the receptor proteins specific for that transmitter substance are only located on the postsynaptic membrane.

Discuss other roles of synapses, including the fact that one neurone can have many synapses relating to it, thus allowing interconnection of numerous nerve pathways; this increases the range of responses which can take place to a particular stimulus and allows more information to be collected. Excitatory and inhibitory synapses provide more flexibility in response, so leading to a wider range of behaviour.

If time allows, students could carry out some simple investigations into learning, which involves synapses.

### Class activities

1. Make notes explaining why synapses ensure one-way transmission of nerve impulses.
2. Explain the benefits in synapses allowing the interconnection of nerve pathways.

### Learning resources

[http://www.skool.ie/skool/examcentre\\_sc.asp?id=2879](http://www.skool.ie/skool/examcentre_sc.asp?id=2879)

provides a summary in bullet points but the detail needs discussion.

**AS and A Level Biology** (Chapter 19, pp. 288-289) covers this learning outcome by stating three main roles of synapses and then explains in greater detail, using examples to help understanding.

**Practical Advanced Biology** has ideas for investigations into learning in small mammals and in humans.

| AO | Learning outcomes   | Suggested Teaching activities  | Learning resources  |
|----|---|--|---|
| N  | <p>(l) explain what is meant by the term <i>endocrine gland</i>;</p> <p>(m) describe the cellular structure of an islet of Langerhans from the pancreas and outline the role of the pancreas as an endocrine gland;</p> | <p>Students will have already covered the differences between the nervous and endocrine systems, and will have knowledge of the hormone ADH when they studied the kidney. With class discussion and verbal question and answer, they should know be able to list some glands of the body, understand that a gland is an organ (or tissue) that has specialised cells which produce a secretion and they should begin to make distinctions between endocrine (ductless) and exocrine glands. Use examples that are familiar to students. Ask students to think about the final destination of the secretions of the glands – they should be able to suggest that endocrine glands release hormones to act at a distance from their location. Use the term <i>target</i> cells / tissue .Discuss also endocrine glands as effectors. As a summary ask students to make general statements about the function of endocrine glands.</p> <p>Show students a diagram or a model showing the main organs in the body, asking them to name and point out the organs that they know. Ensure that they can locate the pancreas and discuss with them its dual role as a ducted gland which secretes pancreatic juice into the pancreatic duct and then into the duodenum; and as an endocrine gland which secretes insulin and glucagon. Detail only of the endocrine areas is required, so progress to the cellular structure of the islets of Langerhans.</p> <p><b>Class activities</b></p> <ol style="list-style-type: none"> <li>1. Write a definition of an endocrine gland.</li> <li>2. Give a brief explanation of the differences between: <ul style="list-style-type: none"> <li>• excretion and secretion</li> <li>• an endocrine gland and an exocrine gland (give examples)</li> </ul> </li> <li>3. Explain how the pancreas can be considered to be an organ that has both endocrine and exocrine functions.</li> <li>4. Locate islets of Langerhans from prepared slides, and make labelled, annotated drawings from the sections.</li> </ol> | <p><a href="http://www.emc.maricopa.edu/faculty/farabee/biobk/biobookendocr.html">http://www.emc.maricopa.edu/faculty/farabee/biobk/biobookendocr.html</a><br/>for interested students</p> <p><a href="http://www.udel.edu/Biology/Wags/histopage/colpage/cp/cp.htm">http://www.udel.edu/Biology/Wags/histopage/colpage/cp/cp.htm</a><br/>images of the cellular structure of the pancreas</p> <p><b>AS and A Level Biology</b> (Chapter 19, pp. 270-272) gives a clear explanation of endocrine glands (also has an overview diagram of the main endocrine and exocrine glands) and gives details of the structure of the pancreas.</p> <p>For a definition of an endocrine gland see page 37 of the <b>2012 Cambridge International A &amp; AS Level Biology Syllabus, code 9700</b>.</p> <p><b>Bio Factsheet 38: Animal hormones and hormone action</b><br/>Has a summary of differences between the nervous and endocrine systems, plus information about endocrine organs, hormones and hormone action.</p> <p><b>Comprehensive Practical Biology for A Level and Practical Advanced Biology</b> both contain a practical exercise looking at the microscopic structure of the pancreas. The CD-ROM: <b>Images of Biology for Advanced Level</b>, pub. Nelson Thornes has good images and <b>Bioscope</b> also has images of sections of the pancreas.</p> |

| AO | Learning outcomes  | Suggested Teaching activities  | Learning resources   |
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| N  | (n)<br>explain how the blood glucose concentration is regulated by negative feedback control mechanisms, with reference to insulin and glucagon; | <p>Students may already know about the role of insulin in reducing blood glucose concentrations, but may be less knowledgeable about glucagon. Ask: 'why is it important for blood glucose concentration to be kept relatively constant?' Use question and answer to establish draw on the role of glucose in the body and their knowledge of osmosis and respiration, in order to predict what might happen if blood glucose rises too high or falls too low. Students should know that normally concentrations are between 90-120mg of glucose 100cm<sup>-3</sup> blood and that in healthy people oscillations around the norm concentration is inevitable.</p> <p>Raise knowledge to A level by helping students to understand the effects of the hormones insulin and glucagon (method of communication). Students should also know that the β and α cells act as receptors by detecting the changing blood glucose concentration (stimulus). Point out the importance of accurate spelling as both glucagon and glycogen are terms used in the topic. Students may be interested in knowing about the effect of diabetes mellitus on the control of blood glucose concentration, which links in with the use of genetic engineering to produce insulin (Section R)</p> | <p>'glucagon and insulin negative feedback' on Google images will give students plenty of ideas in order to produce their own flow chart</p> <p><a href="http://www.biologyreference.com/BI-Ce/Blood-Sugar-Regulation.html">http://www.biologyreference.com/BI-Ce/Blood-Sugar-Regulation.html</a><br/>readable account, also acknowledging (at the end of the article) the work of Dorothy Hodgkin, who worked out the 3-D structure of insulin after 35 years of research.</p> <p><a href="http://www.mydr.com.au/gastrointestinal-health/pancreas-and-insulin">http://www.mydr.com.au/gastrointestinal-health/pancreas-and-insulin</a><br/>a straightforward summary</p> <p><b>AS and A Level Biology</b> (Chapter 19, pp. 272-274) covers this topic at an appropriate level and goes on to discuss diabetes mellitus and the advantages of taking human insulin.</p> |
|    |  | <p><b>Class activities</b></p> <ol style="list-style-type: none"> <li>1. List the main reasons for the importance of keeping blood glucose constant.</li> <li>2. Describe the ways that (i) insulin acts to reduce and (ii) glucagon acts to increase, blood glucose concentration, indicating for each the main target tissues/organs.</li> <li>3. Draw a flow chart to show how the secretion of insulin and glucagon controls the blood glucose concentration by negative feedback mechanisms. Add annotations and/or bullet points, including use of the terms <i>homeostasis</i>, <i>stimulus</i>, <i>receptor effector</i> and <i>negative feedback</i>.</li> <li>4. Describe the sequence of events occurring in a person's body after having a carbohydrate-rich meal, to illustrate homeostasis.</li> </ol>   | <p><b>Bio Factsheet 145:</b> <i>Blood sugar and its control</i></p>  |

| AO | Learning outcomes  | Suggested Teaching activities  | Learning resources   |
|----|--|--|--|
| N  | (o) outline the need for, and the nature of, communication systems within flowering plants to respond to changes in the internal and external environment; | <p>Remind students of the need for a receptor, communication method and effector to allow organisms, including plants as multicellular organisms, to respond to changes in their environment. Ask students: how does this happen in plants? Students should be able to describe xylem and the transpiration stream and phloem and mass flow (from the AS course). Discuss transport also by diffusion and active transport and remind them of plasmodesmata between neighbouring plant cells. Introduce the concept of plant hormones (or use the term <i>plant growth regulators</i>) as the communication method, and draw parallels with animal hormones.</p> <p><b>Class activities</b></p> <ol style="list-style-type: none"> <li>1. List the internal and external changes (revise the term stimulus) that a plant needs to respond to.</li> <li>2. Working as a group draw a large diagram of a plant and label its communication systems. After discussion and research, label the plant's receptors and effectors.</li> <li>3. Research plant hormones and write a comparison with animal hormones (compare = similarities and differences).</li> </ol> | <p><a href="http://www.plant-hormones.info/index.htm">http://www.plant-hormones.info/index.htm</a> provides a history and a list of functions of all the main plant hormones</p> <p><b>AS and A Level Biology</b> (Chapter 19, p. 289) provides a short introduction to communication in plants and gives an overview of plant hormones.</p> <p><b>Bio Factsheet 133: Comparing Chemical Communication in Plants and Animals</b></p> |

| AO | Learning outcomes                                       | Suggested Teaching activities   | Learning resources   |
|----|---|---|--|
| N  | (p)<br>describe the role of auxins in apical dominance; | <p>Use plants with growing points removed and others with them intact to show students how the presence of an apical bud prevents the growth of lateral buds, and explain the role of auxin in this inhibition. Give examples of plants, that students are likely to know, showing different levels of apical dominance, e.g.</p> <p>strong - <i>Helianthus annuus</i> (sunflower), <i>Tradescantia</i>, <i>Avena sativa</i> (oat)</p> <p>intermediate / partial - <i>Phaseolus vulgaris</i> (common bean), <i>Pisum sativum</i> (pea), <i>Vicia faba</i> (broadbean)</p> <p>weak / no - <i>Arabidopsis</i>, <i>Coleus</i>, <i>Triticum</i> (wheat)</p> <p>As background information, it is worth mentioning to students that apical dominance has a genetic basis and varies with different species and cultivars. Also point out that plant control and coordination often involves an interaction with more than one type of plant hormone. Knowledge of many aspects of plant communication is still unclear – the level of detail given in <b>AS and A Level Biology</b> can serve as a guideline.</p> <p><b>Class activities</b></p> <ol style="list-style-type: none"> <li>1. Write a definition of apical dominance.</li> <li>2. Give an outline summary of the role of auxins in apical dominance.</li> <li>3. Research and give examples of plants showing different levels of apical dominance.</li> <li>4. Design and carry out experiments that involve removing the apical bud from growing shoots and comparing with those with intact apical buds.</li> <li>5. Design and carry out investigations into the effect of external factors on apical dominance e.g. <i>Coleus</i> grown under low light conditions is much less branched than <i>Coleus</i> grown under bright light .</li> </ol> | <p><a href="http://plantphys.info/apical/apical.html">http://plantphys.info/apical/apical.html</a><br/>very good explanation of apical dominance, including the effect of different concentrations of auxin</p> <p><a href="http://users.rcn.com/jkimball.ma.ultranet/BiologyPages/A/Auxin.html#apical">http://users.rcn.com/jkimball.ma.ultranet/BiologyPages/A/Auxin.html#apical</a><br/>information about apical dominance</p> <p><a href="http://ddr.nal.usda.gov/bitstream/10113/68/1/IND20583449.pdf">http://ddr.nal.usda.gov/bitstream/10113/68/1/IND20583449.pdf</a><br/>background: article about the evolution of apical dominance in maize – read the introduction and see the photos</p> <p><a href="http://www-saps.plantsci.cam.ac.uk/worksheets/ssheets/sheet6.htm">http://www-saps.plantsci.cam.ac.uk/worksheets/ssheets/sheet6.htm</a><br/>a protocol for an investigation which includes the effect of IAA on growth of lateral buds.</p> <p><a href="http://www-saps.plantsci.cam.ac.uk/records/rec140.htm">http://www-saps.plantsci.cam.ac.uk/records/rec140.htm</a><br/>advice on how to plan investigations to show apical dominance</p> <p><b>AS and A Level Biology</b> (Chapter 19, pp. 289-290) concentrates specifically on the role of auxins in apical dominance.</p> |

| AO | Learning outcomes   | Suggested Teaching activities  | Learning resources   |
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| N  | (q)<br>describe the roles of gibberellins in stem elongation and in the germination of wheat or barley; | <p>Discuss how cell division and cell elongation will lead to plant growth and stem elongation. Ensure that students know the difference between cell growth and cell elongation.</p> <p><b>Class activities</b></p> <ol style="list-style-type: none"> <li>1. Carry out practical work to investigate the effect of gibberellic acid on stem (hypocotyl) elongation and on seed germination (barley).</li> <li>2. Summarise the effects of gibberellins on stem elongation and on seed germination using annotated diagrams.</li> <li>3. Organise a set of statements to show the correct sequence of events in the germination of a seed.</li> </ol> | <p><a href="http://www.tutorvista.com/content/biology/biology-iv/plant-growth-movements/gibberellins.php">http://www.tutorvista.com/content/biology/biology-iv/plant-growth-movements/gibberellins.php</a><br/>a set of photographs that show the effect of different concentrations of gibberellic acid on stem elongation in dwarf pea plants</p> <p><a href="http://users.rcn.com/jkimball.ma.ultranet/BiologyPages/G/Gibberellins.html">http://users.rcn.com/jkimball.ma.ultranet/BiologyPages/G/Gibberellins.html</a><br/>detailed, but includes relevant information for interest:</p> <p><a href="http://home.earthlink.net/~dayvdanls/plant_grow.htm">http://home.earthlink.net/~dayvdanls/plant_grow.htm</a><br/>discovery of a protein, named expansin, involved in cell elongation</p> <p><a href="http://homes.bio.psu.edu/expansins/">http://homes.bio.psu.edu/expansins/</a><br/>more information about expansins</p> <p><b>AS and A Level Biology</b> (Chapter 19, pp. 290-291) covers this topic at an appropriate level.</p> <p><b>Practical Advanced Biology</b>, has protocols for an investigation into the effect of gibberellic acid on pea seedlings, and on the germination of cereal grains.</p> <p><b>Bio Factsheet 118: Germination</b></p> |

| AO | Learning outcomes  | Suggested Teaching activities  | Learning resources  |
|----|--|--|---|
| N  | (r)<br>describe the role of abscisic acid in the closure of stomata; | <p>Remind students of the mechanism by which stomata open and close (or cover this topic here if it was not dealt with in Unit 1) and explain the role of abscisic acid as a 'stress hormone' in helping plants to survive difficult environmental conditions. Remind students of the need to think synoptically – stomatal closure has a bearing on transpiration and photosynthesis. In addition, the mechanism of closure uses knowledge and understanding from AS topics:</p> <ul style="list-style-type: none"> <li>• plant cell structure</li> <li>• cell membrane proteins</li> <li>• diffusion</li> <li>• active transport</li> <li>• osmosis</li> <li>• water potential gradients</li> </ul> <p><b>Class activities</b></p> <ol style="list-style-type: none"> <li>1. Review the above AS topics, giving verbal definitions of the three different mechanisms of transport across membranes.</li> <li>2. Draw a series of annotated diagrams to explain the mechanism and processes involved in stomatal opening and closure.</li> <li>3. If not already carried out in Unit 1, make temporary slides of epidermal strips or use prepared slides to observe guard cells and stomata.</li> </ol> | <p><a href="http://users.rcn.com/jkimball.ma.ultranet/BiologyPages/A/ABA.html">http://users.rcn.com/jkimball.ma.ultranet/BiologyPages/A/ABA.html</a><br/>information on different roles of abscisic acid – note that students only need to know about stomatal closure</p> <p><a href="http://www.nicksnowden.net/Other_pages/546_Control_Coordination_and_Homeostasis.pdf">http://www.nicksnowden.net/Other_pages/546_Control_Coordination_and_Homeostasis.pdf</a><br/>summary notes that match well to these learning outcomes</p> <p><b>AS and A Level Biology</b> (Chapter 19, p. 291) gives a good explanation of the mechanisms involved in stomatal closure. Chapter 16, p.217, Fig.16.9 is relevant here. Details of leaf abscission are not required, but this may be of interest to students and is also an example of how different plant hormones interact to bring about a response.</p> <p>These two Bio Factsheets have summaries and extra background information:<br/><b>Bio Factsheet 48: Tackling exam questions: plant growth substances</b></p> <p><b>Bio Factsheet 111: Plant Growth Substances</b></p> |