OCR
Oxford Cambridge and RSA

Cambridge **TECHNICALS LEVEL 3**

Cambridge TECHNICALS 2016

APPLIED SCIENCE

Unit 8 – Cell biology
DELIVERY GUIDE

Version 2

CONTENTS

INTRODUCTION

This Delivery Guide has been developed to provide practitioners with a variety of creative and practical ideas to support the delivery of this qualification. The Guide is a collection of lesson ideas with associated activities, which you may find helpful as you plan your lessons.

OCR has collaborated with current practitioners to ensure that the ideas put forward in this Delivery Guide are practical, realistic and dynamic. The Guide is structured by learning outcome so you can see how each activity helps you cover the requirements of this unit.

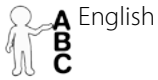
We appreciate that practitioners are knowledgeable in relation to what works for them and their learners. Therefore, the resources we have produced should not restrict or impact on practitioners' creativity to deliver excellent learning opportunities.

Whether you are an experienced practitioner or new to the sector, we hope you find something in this guide which will help you to deliver excellent learning opportunities.

If you have any feedback on this Delivery Guide or suggestions for other resources you would like OCR to develop, please email resources.feedback@ocr.org.uk.

OPPORTUNITIES FOR ENGLISH AND MATHS SKILLS DEVELOPMENT AND WORK EXPERIENCE

We believe that being able to make good progress in English and maths is essential to learners in both of these contexts and on a range of learning programmes. To help you enable your learners to progress in these subjects, we have signposted opportunities for English and maths skills practice within this resource. We've also identified any potential work experience opportunities within the activities. These suggestions are for guidance only. They are not designed to replace your own subject knowledge and expertise in deciding what is most appropriate for your learners.



English

Maths


Work

Please note

The activities suggested in this Delivery Guide **MUST NOT** be used for assessment purposes. The timings for the suggested activities in this Delivery Guide **DO NOT** relate to the Guided Learning Hours (GLHs) for each unit.

Assessment guidance can be found within the Unit document available from http://www.ocr.org.uk/. The latest version of this Delivery Guide can be downloaded from the OCR website.

UNIT AIM

Cell biology, or cytology, is the study of cells. As the cell is the basic unit of almost all living things, cytology is one of the most important areas of biological research.

This unit examines how these observations enable cytologists to reveal details of cell structure, their fine structure or ultrastructure, and how parts of the cell function and interact with each other. You will use cell counting techniques, along with staining techniques to identify types of cells, components within them, and products they make.

Cytology is important to the developmental biologist. Through the study of this unit, you will develop an understanding of cell division and differentiation, where they become adapted to fulfil specific roles. The unit examines how these processes occur, with genes being expressed in some specialist cells, but not in others.

The cells involved in differentiation are called stem cells. You will research the different types of stem cell and their potential to produce the different types of cells required. As part of this unit, you will have the opportunity to research and present a case study on the ground-breaking area of stem cell-based therapies. Some of the techniques are controversial, but they offer cell replacement therapies and regenerative medicine, and with this the possibility of the management or cure of diseases and conditions that are currently untreatable.

Unit 8 Cell biology	
LO1	Understand the functions of the plasma membrane and endomembrane systems
LO2	Be able to use cytological techniques
LO3	Understand the cell cycle and the importance of mitosis
LO4	Understand the process and significance of differentiation
LO5	Understand the potential of stem cells in medical therapies

To find out more about this qualification, go to: http://www.ocr.org.uk/qualifications/vocational-education-and-skills/cambridge-technicals-applied-science-level-3-certificate-extended-certificate-foundation-diploma-diploma-extended-diploma-05847-05849-05879-05874-2016-suite/

RELATED ACTIVITIES

The Suggested Activities in this Delivery Guide listed below have also been related to other Cambridge Technicals in Laboratory Skills units/Learning Outcomes (LOs). This could help with delivery planning and enable learners to cover multiple parts of units.

This unit (Unit 8)	Title of suggested activity	Other units/LOs	
LO1	The structure of the plasma membrane Constructing a model of the plasma membrane Endocytosis and exocytosis Endomembrane systems Cell signalling	Unit 1 Science fundamentals	LO3 Understand cell organisation and structures
LO2	Using the light microscope Investigating the limits of light microscopy Extending the limits of light microscopy	Unit 2 Laboratory techniques	LO4 Be able to examine and record features of biological samples
	Using staining techniques	Unit 3 Scientific analysis and reporting	LO6 Be able to use modified, extended or combined laboratory techniques in analytical procedures
LO3	The significance of mitosis The stages of mitosis Observing the stages of mitosis in plant cells The cell cycle Checkpoints and arresting cell division	Unit 5 Genetics	LO1 Understand the importance of meiosis
LO4	Differentiation	Unit 1 Science fundamentals	LO3 Understand cell organisation and structures
		Unit 5 Genetics	LO1 Understand the importance of meiosis
	Gene expression	Unit 5 Genetics	LO4 Understand the impact of an innovation in an application of genomics
LO5	Stem cells	Unit 1 Science fundamentals	LO3 Understand cell organisation and structures

KEY TERMS

Explanations of the key terms used within this unit, in the context of this unit	
Key term	**Explanation**
Differentiation	The process by which cells become specialised. In a differentiated cell, some genes are expressed; some are switched off.
Mitosis	The type of cell division where two daughter cells are produced, each with the same number of chromosomes.
Multipotent	Stem cells that have the capacity to develop into types present in a specific tissue or organ. Most adult stem cells are multipotent.
Pluripotent	A type of stem cell that can develop into all cell types that make up the body, cells of the placenta. Unlike totipotent cells, they could not develop into a complete organism. 'Embryonic stem cells' are pluripotent.
Resolution	The ability to tell that two points that are very close together are distinct objects rather than just one.
Stem cell	An unspecialised cell. Cells in the early embryo can all be termed as stem cells. A small number of stem cells are retained in the adult but can differentiate into fewer cell types.
Totipotent	Can develop into all types of cell in the body. They are embryonic cells in the first couple of cell divisions after fertilisation.
Unipotent	Can differentiate into one cell type only.

MISCONCEPTIONS

Some common misconceptions and guidance on how they could be overcome		
What is the misconception?	**How can this be overcome?**	**Resources which could help**
Electron microscopes are always used to provide images of higher magnification	Learners should be referred to some scanning electron micrographs, in particular, where magnifications are quite low.	Magnification and resolution Science Learning Hub, University of Waikato http://sciencelearn.org.nz/Contexts/Exploring-with-Microscopes/Science-Ideas-and-Concepts/Magnification-and-resolution A useful comparison of light and electron microscopes.
Electron microscopes would always be the preferred microscope to use	Learners should appreciate that for routine use, for instance in pathology labs, the light microscope would be the microscope of choice and is better at revealing salient features of cells, or changed cells. New light microscopical techniques have reduced the gap between the capabilities of light and electron microscopes. It should also be noted that because of the nature of the electron, they are not used for examining living cells.	What is Light Microscopy? John Innes Centre https://www.jic.ac.uk/microscopy/intro_LM.html A very good overview of light microscopical techniques.
Cells spend much of their time dividing	It should be emphasised that cells spend a short period of time in mitosis. Learners could do some estimates of the time spent, based on data on the Internet, or from their own slides.	The cell cycle, mitosis and meiosis University of Leicester – Virtual Genetics Education Centre http://www2.le.ac.uk/departments/genetics/vgec/schoolscolleges/topics/cellcycle-mitosis-meiosis An excellent website covering a range of cell biology topics and links to resources.
Stem cell therapies are new	Transplants of haemopoietic stem cells ('bone marrow transplants') were first carried out in 1968. It should also be emphasised that the main source of this type of stem cell is now blood vessels.	History of stem cell research UK Stem Cell Foundation (UKSCF) http://www.ukscf.org/about-stem-cell-research/history.html Gives a concise overview of the history of stem cell research.
Stem cells can be transplanted into patients and are a panacea	Cells for transplant are usually developed from stem cells. Stem cell research and therapy are in their infancy.	What are Stem Cells? University of Nebraska Medical Center (2016) http://www.unmc.edu/stemcells/stemcells/index.html Sets out the types of stem cells and has sections on 'can doctors use stem cells to treat patients?' and 'pros and cons of using various stem cells'.

SUGGESTED ACTIVITIES

LO No:	1		
LO Title:	**Understand the functions of the plasma membrane and endomembrane systems**		
Title of suggested activity	**Suggested activities**	**Suggested timings**	**Also related to**
The structure of the plasma membrane	Learners will have looked at the role of the plasma membrane in Unit 1, and this could be recapped and developed. Integral to the understanding of plasma membrane function is a knowledge of its structure. A good starting point for a discussion of its structure would be to put this into a historical perspective: • The Davson-Danielli model of 1935 of a lipid bilayer sandwiched between protein, proposed as a result of chemical analyses of the plasma membrane and supported by its appearance with the electron microscope • The Singer-Nicolson model of 1972 – the 'fluid-mosaic' model • The current model of membrane structure, essentially that of Singer-Nicolson but updated to account for experimental observations. Goñi, F.M. (2104) The basic structure and dynamics of cell membranes: An update of the Singer–Nicolson model. *Biochim. Biophys. Acta*, 1838 1467–1476 An excellent, contemporary overview of plasma membrane structure. O'Connor, Clare, Adams, Jill U., and Fairman, Jennifer (2010) *Essentials of Cell Biology*. Cambridge, MA: NPG Education. http://www.nature.com/scitable/ebooks/essentials-of-cell-biology-14749010/contents An ebook that provides a very good introduction to cell biology. Unit 3 describes the structure and function of cell organelles. Cell Biology Research on Facebook Cell Biology Research Community https://www.facebook.com/CellBiologyResearch Updates on research news, recent advances, equipment, images, and additional resources in the field of cellular biology.	1 hour	Unit 1 LO3

Title of suggested activity	Suggested activities	Suggested timings	Also related to
Constructing a model of the plasma membrane	A short activity in which learners construct a model of the plasma membrane in order to derive an understanding/demonstrate an understanding of its structure. A number of suggestions are available on the internet but learners could use their own initiative in the selection of materials. Learning might be supplemented by an appropriate visit, e.g. to the Wellcome Museum. Build-A-Membrane Genetic Science Learning Center http://teach.genetics.utah.edu/content/cells/BuildAMembrane.pdf Cut, fold, and paste biomolecules to create a three-dimensional cell membrane with embedded proteins.	1 hour	Unit 1 LO3
Investigating transport across membranes – passive mechanisms	The plasma membrane should be discussed as a selectively permeable membrane. This could be discussed in conjunction with the substances transported and membrane structure. Learners could research the range of substances that are transported by diffusion. They should then develop ideas about how facilitated diffusion works and the role of membrane-spanning transport proteins, e.g. in glucose transport. Plasma Membrane Biology Guide http://www.biologyguide.net/cells/plasma_membrane.htm Useful notes on the plasma membrane. Diffusion, Osmosis and Movement across a Membrane University of Illinois at Chicago http://bio100.class.uic.edu/mike/spring2003/lect07.htm A good overview of passive and active transport mechanisms (and cell communication). Movement across membranes California Polytechnic State University http://www.calpoly.edu/~bio/EPL/pdfs/SampleLectureBIO361.pdf A presentation that gives an overview of passive and active transport mechanisms. Passive and Active Transport University of Fribourg http://www.unifr.ch/biology/assets/files/schneiter/lectures/voet_ch10_transport.pdf A presentation that gives a more detailed overview of transport mechanisms.	1 hour	

Title of suggested activity	Suggested activities	Suggested timings	Also related to
Investigating transport across membranes – active transport	Learners should appreciate that entry of some substances into the cell requires movement against a concentration gradient. Learners could discuss examples of this, e.g. the movement of glucose across the intestinal wall. The requirement for energy could be discussed as a factor that distinguishes active transport from facilitated diffusion. Learners should be able to describe active transport pumps, including, but not restricted to, the sodium-potassium pump. They could construct simple animations to illustrate the processes involved. Diffusion, Osmosis and Movement across a Membrane University of Illinois at Chicago http://bio100.class.uic.edu/mike/spring2003/lect07.htm A good overview of passive and active transport mechanisms (and cell communication). Movement across membranes California Polytechnic State University http://www.calpoly.edu/~bio/EPL/pdfs/SampleLectureBIO361.pdf A presentation that gives an overview of passive and active transport mechanisms. Passive and Active Transport University of Fribourg http://www.unifr.ch/biology/assets/files/schneiter/lectures/voet_ch10_transport.pdf A presentation that gives a more detailed overview of transport mechanisms.	1 hour	
Endocytosis and exocytosis	Learners could research these processes, involving the movement of materials into and out of cells, respectively, via membranous vesicles. They could draw diagrams/displays or animations to illustrate the processes. Endocytosis and Exocytosis McGraw Hill Education http://highered.mheducation.com/olcweb/cgi/pluginpop.cgi?it=swf::535::535::/sites/dl/free/0072437316/120068/bio02.swf::Endocytosis%20and%20Exocytosis An animation of the processes. BioCoach Activity. Concept 2: Endocytosis and Exocytosis Pearson – The Biology Place http://www.phschool.com/science/biology_place/biocoach/biomembrane2/cytosis.html A simple but effective animation of the processes.	1 hour	Unit 1 LO3

Title of suggested activity	Suggested activities	Suggested timings	Also related to
Endomembrane systems	Learners will have considered the functions of components of the endomembrane system in eukaryotic cells in Unit 1. They could now look at these structures – the endoplasmic reticulum (rough and smooth) and Golgi apparatus, along with lysosomes and vesicles. They could produce a series of diagrams, a series of models or an animation that provides an explanation of the functions of the endomembrane system, in the production of proteins and lipids and their modification, packaging, transport and secretion. They will have studied the structures in Unit 1 using electron microscopy, but should appreciate and demonstrate that these organelles are not static, but make up a constantly changing, dynamic system. O'Connor, Clare, Adams, Jill U., and Fairman, Jennifer (2010) *Essentials of Cell Biology*. Cambridge, MA: NPG Education http://www.nature.com/scitable/ebooks/essentials-of-cell-biology-14749010/contents A very good introduction to cell biology. Unit 3 describes the structure and function of cell organelles. BioCoach Activity. Concept 1: Dynamic Membrane Flow Through the Cell Pearson – The Biology Place http://www.phschool.com/science/biology_place/biocoach/biomembrane2/flow.html A very simple but effective animation of the processes. Endomembrane system Brooklyn College http://academic.brooklyn.cuny.edu/biology/bio4fv/page/endomem.htm A simple but very effective animation of the processes, with links to a little more detail on the organelles involved. Endoplasmic Reticulum, Golgi Apparatus, and Lysosomes Scitable by Nature Education http://www.nature.com/scitable/topicpage/endoplasmic-reticulum-golgi-apparatus-and-lysosomes-14053361 There is a series of articles on cell biology on the Scitable by Nature Education website: http://www.nature.com/scitable	1 hour	Unit 1 LO3

Title of suggested activity	Suggested activities	Suggested timings	Also related to
Cell signalling	The principles of cell signalling and significance could be discussed before learners carry out their own research. Learners should appreciate, on a simple level initially, that cells in organisms constantly communicate with each other. It is the plasma membrane that forms the point of contact between other cells and the cell's environment. Learning could perhaps begin by considering that as multicellular organisms have evolved, mechanisms must also have developed to ensure that activities of cells must be coordinated. The outcome of learners' research could be a large chart or wall display, explaining the various roles of cell signalling. It is essential that learners give a broad overview of types of cell signalling pathway in their explanations, and not become overly focused on detail in a limited number of types. Learners should appreciate that different signalling pathways are used to control the life history of cells – from their birth during the process of cell division and proliferation, their differentiation into specific cell types to carry out different cell functions, and finally their death. Cell signalling systems regulate a wide range of specific processes in adult cells, such as contraction, secretion, metabolism, tissue repair, information processing in neurones and sensory perception. Cell communication occurs through *chemical* signalling, e.g. through neurotransmitters, hormones, growth factors, and *electrical* signalling, e.g. in the heart and brain. The mechanisms and significance of cell signalling should be put into context in that it is giving scientists a greater insight into defects responsible for many human diseases. Altered signalling is involved in many forms of cancer. O'Connor, Clare, Adams, Jill U., and Fairman, Jennifer (2010) *Essentials of Cell Biology*. Cambridge, MA: NPG Education. Unit 4: How Do Cells Sense Their Environment? Unit 5: How Do Cells Know When to Divide? http://www.nature.com/scitable/ebooks/essentials-of-cell-biology-14749010/contents A very good introduction to cell biology. Diffusion, Osmosis, andMovement Across A Membrane University of Illinois at Chicago http://bio100.class.uic.edu/mike/spring2003/lect07.htm A good introduction to cell communication (if a little dated).	2 hours	Unit 1 LO3

Title of suggested activity	Suggested activities	Suggested timings	Also related to
Cell signalling (continued)	BioCoach Activity. Concept 3: Membrane Surface Receptors Pearson – The Biology Place http://www.phschool.com/science/biology_place/biocoach/biomembrane2/surface.html A very simple but effective animation of the principles. Cell Signaling Scitable by Nature Education (2014) http://www.nature.com/scitable/topicpage/cell-signaling-14047077 There is a series of articles on cell biology and stem cells on the Scitable by Nature Education website: http://www.nature.com/scitable Berridge, M.J. (2014) Cell Signalling Biology; doi: 10.1042/csb0001001 http://www.cellsignallingbiology.org/csb/001/csb001.htm An excellent, detailed overview of the topic, at a high level. Currently the definitive reference on cell signalling.		

SUGGESTED ACTIVITIES

LO No:	2		
LO Title:	**Be able to use cytological techniques**		
Title of suggested activity	**Suggested activities**	**Suggested timings**	**Also related to**
Using the light microscope	The setting up of the light microscope should be familiar to most learners, but it is worth recapping this. Learners could have the opportunity to repeat simple preparations that they will have carried out in Unit 1, e.g. of squamous epithelium from the mouth and onion epidermal cells. Using the microscope. Basic tutorial Micrographia http://www.micrographia.com/tutoria/micbasic/micbpt01/micb0100.htm A very good tutorial on setting up the light microscope on this and subsequent pages.	1 hour	Unit 2 LO4
Using staining techniques	Learners could now use differential staining techniques to identify cells, organelles, inclusions and secretions. They should begin by using the Gram stain to identify a Gram positive, e.g. *Bacillus subtilis*, and gram-negative bacterium, e.g. *Escherichia coli*. This should be linked back to cell wall and membrane structure. Gram staining techniques should be a minimum. Ideally, learners should then use staining techniques to identify cell organelles, inclusions or secretions in mammalian cells/tissues. These might include: • haematoxylin and eosin (haematoxylin for the nucleus; eosin for the cytoplasm) • Alcian blue for mucopolysaccharides produced by mucus-secreting cells • Masson's trichrome stain for blood, smooth and striated muscle and mucus. The staining procedures are best carried out using paraffin wax sections and learners could experience the sequence of histological procedures used to produce permanent slides. Learners should become proficient in preparing slides and could set up a series of illustrated protocols for the various techniques. These could be supported by scale diagrams (Unit 2) or scaled, digital images. Basic Cellular Staining Bruckner, Monica Z. (2011) http://serc.carleton.edu/microbelife/research_methods/microscopy/cellstain.html Stains used in microbiology; also includes an overview of preparatory techniques. Special Stains in Histology; Histology Procedure Manuals University of Utah Eccles Health Sciences Library http://library.med.utah.edu/WebPath/HISTHTML/STAINS/STAINS.html http://library.med.utah.edu/WebPath/HISTHTML/MANUALS/MANUALS.html An excellent overview of histological stains and other histological techniques.	2 hours	Unit 3 LO6

Title of suggested activity	Suggested activities	Suggested timings	Also related to
Immunohistochemistry	An extension of using histological stains to identify specific regions of cells or tissues is immunohistochemistry or IHC. This refers to the process of detecting antigens in cells of a tissue section using the principle of antibodies binding specifically to target antigens: for instance, those associated with tumour cells. Commonly, the antibody is conjugated to an enzyme so that the area is rendered visible. Learners should appreciate a range of applications including its use in the diagnosis of cancerous tumours. The technique is also used in drug development and biological research. Technological advances have produced automated systems for high-throughput sample preparation and staining. Samples can be viewed with either light or fluorescence microscopy. There are a number of excellent information sources on the internet, and learners could carry out their own research to produce an illustrated information leaflet or web page. Immunohistochemistry – What is IHC or ICC? Immunohistochemistry.org http://www.immunohistochemistry.org.uk/Home.html An overview of the principles and procedures. Overview of Immunohistochemistry ThermoFisher Scientific https://www.thermofisher.com/uk/en/home/life-science/protein-biology/protein-biology-learning-center/protein-biology-resource-library/pierce-protein-methods/overview-immunohistochemistry.html Another good overview that also includes a historical perspective. An Animated Guide to Immunohistochemistry Leica Biosystems http://www.leicabiosystems.com/pathologyleaders/an-animated-guide-to-immunohistochemistry/ Another useful guide to immunohistochemistry.	1 hour	

Title of suggested activity	Suggested activities	Suggested timings	Also related to
Investigating the limits of light microscopy	Learners will have observed that working with a microscope on high power, the image is much less bright. The lens is also very close to the microscope slide. *Very* high magnifications are not possible with the light microscope because of the light gathering ability of the microscope and the short working distances of high power lenses. The highest magnification possible is around x1500. Learners could examine some preparations using oil immersion microscopy. The terms magnification and resolution should be reinforced. They could research the limits of light and electron microscopy in terms of magnification and resolution. They could calculate possible resolution from a theoretical point of view and make comparisons with the limits of resolution currently obtainable. Magnification and resolution Science Learning Hub, University of Waikato http://sciencelearn.org.nz/Contexts/Exploring-with-Microscopes/Science-Ideas-and-Concepts/Magnification-and-resolution A useful comparison of light and electron microscopes. Introduction to Electron Microscopy San Diego State University College of Sciences http://www.sci.sdsu.edu/emfacility/555class/class1.html A good overview of types of microscopy. Limits to Resolution in the Transmission Electron Microscope The University of Oklahoma http://www.ou.edu/research/electron/bmz5364/resolutn.html Uses principles of optics to understand the limitations of electron microscopy.	1 hour	Unit 2 LO4

Title of suggested activity	Suggested activities	Suggested timings	Also related to
Extending the limits of light microscopy	Learners could go on to research a range of microscopical techniques, including different optical systems and confocal microscopy, which will extend the limits of microscopy. These could be compared with the advantages conveyed by electron microscopy (Unit 2). Learners should appreciate that with recent developments in light microscopy, there has been a decline in the gap between light and electron microscopy. After an initial overview, the activity is best conducted by student research. Light microscopy techniques Radboud University Faculty of Science: Biology http://www.vcbio.science.ru.nl/en/image-gallery/techniek/licht/ A very good overview of light microscopical techniques, with links to more detailed pages. What is Light Microscopy? John Innes Centre https://www.jic.ac.uk/microscopy/intro_LM.html Another very good overview of light microscopical techniques. Super-resolution light microscopy wins chemistry Nobel Stoye, Emma (2014) http://www.rsc.org/chemistryworld/2014/10/super-resolution-light-microscopy-wins-chemistry-nobel Article about overcoming the diffraction limit to allow optical microscopy at the nanoscale.	2 hours	Unit 2 LO4
Using and investigating cell counting techniques	Learners could demonstrate skills in cell counting using a haemacytometer. The use of a yeast cell suspension is recommended. With a drop of methylene blue solution, the task could assume an applied context. Some brewers use this technique to assess yeast cell viability (viable cells will be colourless; dead cells, blue). An optimum concentration of yeast cells should be used to give a countable number of cells (25–100) per large square (1 mm x 1 mm). They should then consider alternative techniques. The Coulter principle should be discussed along with the ability of the Coulter counter to discriminate between cells of different sizes. The significance of this should be discussed, e.g. the ability of a brewer, for instance, to detect bacterial contaminants when carrying out a yeast cell count. Learners are unlikely to have access to a Coulter counter in a college or sixth form laboratory, but perhaps may be introduced to the technique on a laboratory visit. Using a Haemocytometer University of Queensland Diamantina Institute http://www.di.uq.edu.au/sparqhaemocytometer A guide to using a haemacytometer.	2 hours	

Title of suggested activity	Suggested activities	Suggested timings	Also related to
Using and investigating cell counting techniques (continued)	Using a Counting Chamber Rice University Experimental Biosciences http://www.ruf.rice.edu/~bioslabs/methods/microscopy/cellcounting.html Another guide to using a haemacytometer. Cell counting using a Haemocytometer Public Health England https://www.phe-culturecollections.org.uk/technical/ccp/cellcounting.aspx Another guide to using a haemacytometer. Coulter Counters in the Study of Bacteria Coulter Counter http://www.coultercounter.co.uk/coulter-counters-in-the-study-of-bacteria/#more-46 A short overview of the Coulter counter. Coulter Counter Massachusetts Institute of Technology MIT Open Courseware http://ocw.mit.edu/courses/health-sciences-and-technology/hst-410j-projects-in-microscale-engineering-for-the-life-sciences-spring-2007/labs/coulter_counter.pdf A brief guide to the use of the Coulter counter. Multisizer 3 Operator's Manual University of Cambridge Department of Medicine http://www.med.cam.ac.uk/wp-content/uploads/2014/10/Coulter_Manual.pdf An operator manual but contains much useful information.		

SUGGESTED ACTIVITIES

LO No:	3		
LO Title:	**Understand the cell cycle and the importance of mitosis**		
Title of suggested activity	**Suggested activities**	**Suggested timings**	**Also related to**
The significance of mitosis	This section could start with the importance of mitosis in producing genetically identical cells for asexual reproduction, growth and repair. This can be contrasted with meiosis (Unit 5), its importance in halving the chromosome number in gamete formation and leading to genetic variation in sexual reproduction. Learners could produce an information sheet/web page, combining this with the next activity. Learners' descriptions will require accompanying text and perhaps the use of some extended prose to provide a sufficiently detailed response. O'Connor, Clare, Adams, Jill U., and Fairman, Jennifer (2010) *Essentials of Cell Biology*. Cambridge, MA: NPG Education http://www.nature.com/scitable/ebooks/essentials-of-cell-biology-14749010/contents A very good introduction to cell biology. Unit 5: How Do Cells Know When to Divide? includes a good section on mitosis. The cell cycle, mitosis and meiosis University of Leicester – Virtual Genetics Education Centre http://www2.le.ac.uk/departments/genetics/vgec/schoolscolleges/topics/cellcycle-mitosis-meiosis An excellent website covering a range of cell biology topics and links to resources.	2 hours	Unit 5 LO1

Title of suggested activity	Suggested activities	Suggested timings	Also related to
The stages of mitosis	This activity should build on any prior learner knowledge about the stages of mitosis. A good starting point would be to examine the processes microscopically, either with some prepared slides or a video sequence from the internet. In the next activity, learners could observe the stages in their own slides, e.g. mitosis in onion root tips. The temporary preparations can be easily fixed, dehydrated and mounted for future observation, and the preparation of permanent slides is appealing to learners. Basic estimations of the duration of the respective stages can be made by counting the cells in each phase. Learners could describe the stages and events during mitosis. They will have already have studied certain types of cell structure in Unit 1 Science fundamentals, and now it is helpful to introduce them to some additional detail and the involvement of organelles such as centrioles and microtubules. Following the teaching of the stages, learners can demonstrate their understanding of the processes on the work bench, assembling poppet beads as chromosomes (different colours can be added to illustrate genes), string as spindle fibres, and a board marker to illustrate degradation and then re-formation of the nucleus. Some learners may wish to draw and animate sequences using an appropriate ICT package to illustrate the process. This should be linked with the previous activity, with learners preparing an information sheet/web page. O'Connor, Clare, Adams, Jill U., and Fairman, Jennifer (2010) *Essentials of Cell Biology*. Cambridge, MA: NPG Education http://www.nature.com/scitable/ebooks/essentials-of-cell-biology-14749010/contents A very good introduction to cell biology. Unit 5: How Do Cells Know When to Divide? includes a good section on mitosis. The cell cycle, mitosis and meiosis University of Leicester – Virtual Genetics Education Centre http://www2.le.ac.uk/departments/genetics/vgec/schoolscolleges/topics/cellcycle-mitosis-meiosis An excellent website covering a range of cell biology topics and links to resources.	4 hours	Unit 5 LO1

Title of suggested activity	Suggested activities	Suggested timings	Also related to
Observing the stages of mitosis in plant cells	Learners should be given the activity of observing the stages in their own slides, for instance mitosis in onion root tips. Onion root tip squashes provide excellent results. An onion grown for a few days in a beaker of water will yield sufficient root tips. For best results, excised root tips should be fixed in Farmer's fixative (ethanol/ethanoic acid) and then the tissue hydrolysed by being left overnight in hydrochloric acid to soften the tips. Chromosomes should be stained in acetocarmine or Feulgen stain; excellent results are obtained with these in combination. Acetic-orcein is an alternative stain. The temporary preparations can be easily fixed, dehydrated and mounted for future observation, and the preparation of some permanent slides is appealing to learners. Investigating mitosis in allium root tip squash Nuffield Foundation http://www.nuffieldfoundation.org/practical-biology/investigating-mitosis-allium-root-tip-squash One of the many protocols for this activity. Lab Manual for Introductory Cytogenetics PLNT3140 University of Manitoba http://home.cc.umanitoba.ca/~frist/PLNT3140/lab/CytoLabManual.pdf A detailed guide to preparing mitosis slides and karyotypes.	2 hours	Unit 5 LO1
The cell cycle	Learners should research and be familiar with the stages and events of the cell cycle. This could be produced as a large, annotated display. Learners could be given an overview of next-generation sequencing (NGS), and then directed to a series of resources that describes procedures and the implications and applications of these. The cell cycle, mitosis and meiosis University of Leicester – Virtual Genetics Education Centre http://www2.le.ac.uk/departments/genetics/vgec/schoolscolleges/topics/cellcycle-mitosis-meiosis An excellent website covering a range of cell biology topics and links to resources. The Cell Cycle & Mitosis Tutorial University of Arizona, Department of Biochemistry and Molecular Biophysics http://www.biology.arizona.edu/cell_bio/tutorials/cell_cycle/cells2.html An overview of the events of the cell cycle. Cell Cycle and Cell Division Scitable by Nature Education http://www.nature.com/scitable/topic/cell-cycle-and-cell-division-14122649 Another good account of the process.	2 hours	Unit 5 LO1

Title of suggested activity	Suggested activities	Suggested timings	Also related to
Checkpoints and arresting cell division	Learners could consider a cell's use of checkpoints during the cell cycle, and how the potential halting points ensure proper cell division. They could discuss the timing of checkpoints in mitosis and how these have been linked with cancer. Certain medications can introduce stopping points, and learners could assess how these are important in many cancer therapies, e.g. the taxol group and the vinca alkaloids and their effect on the mitotic spindle. Toxicity, tumour types affected, and their unpredictability are all considerations in their use, and learners could examine how new strategies are being researched. Environmental factors – either natural or induced by chemicals or radiation – can also be important in cell cycle arrest in certain organisms, leaving the organism in a type of suspended animation until conditions become more favourable. The recommended approach is that learners produce a formal report or web pages. Darnell, J., Lodish, H., Berk, A., Zipursky, S.L., Matsudaira, P. and Baltimore, D. (2000) *Molecular Cell Biology*. 4th edition. W.H. Freeman, New York. http://www.ncbi.nlm.nih.gov/books/NBK21719/. Outdated, but includes a good introduction to checkpoints in cell-cycle regulation. A 2012 edition of this text is available. Cell Division, Mitosis, and Meiosis University of Illinois at Chicago http://bio100.class.uic.edu/lecturesf04am/lect16.htm Another good introduction to the principles. Gascoigne, K.E. and Taylor, S.S. (2009) How do anti-mitotic drugs kill cancer cells? *Journal of Cell Science* 122: 2579-2585. http://jcs.biologists.org/content/122/15/2579.full A excellent overview of the topic. Chan, K.S., Koh, C.G. and Li, H.Y. (2012) Mitosis-targeted anti-cancer therapies: where they stand. *Cell Death & Disease*. 3, e411; doi:10.1038. http://www.nature.com/cddis/journal/v3/n10/full/cddis2012148a.html An excellent paper, though at a high level.	2 hours	Unit 5 LO1

Title of suggested activity	Suggested activities	Suggested timings	Also related to
Checkpoints and arresting cell division (continued)	Swift, L.H. and Golsteyn, R.M. (2014) Genotoxic anti-cancer agents and their relationship to DNA damage, mitosis, and checkpoint adaptation in proliferating cancer cells. *International Journal of Molecular Sciences.* 15: 3403–3431. http://europepmc.org/articles/PMC3975345 Another excellent paper. Janssen, A. and Medema, R.H. (2011) Mitosis as an anti-cancer target**.** *Oncogene* (2011) 30, 2799–2809. http://www.nature.com/onc/journal/v30/n25/full/onc201130a.html Another excellent paper.		

SUGGESTED ACTIVITIES

LO No:	4		
LO Title:	**Understand the process and significance of differentiation**		
Title of suggested activity	**Suggested activities**	**Suggested timings**	**Also related to**
Differentiation	In Unit 1, learners learned how, as an organism develops, cells differentiate so as to become specialised, in order to perform specific roles. In this unit, they should learn that this process occurs as the zygote develops into a complex multicellular organism, and can also occur in some cells of the adult. Differentiation will change a cell's size, shape, responsiveness to signals, membrane potential and metabolic activity. Learners need to know that in animals, cells that can differentiate into other cell types are called stem cells, and they need to distinguish between totipotent, pluripotent, multipotent and unipotent stem cells. In plants, cells capable of differentiation are called meristematic cells. Learners could write a short description of the process, with examples. The principles of cell differentiation are well-supported by biology textbooks. These are some additional resources: Cell Differentiation and Tissue Scitable by Nature Education http://www.nature.com/scitable/topicpage/cell-differentiation-and-tissue-14046412 This is one of a series of articles on cell biology on the Scitable by Nature Education website: http://www.nature.com/scitable Module 3 – Cellular differentiation Stem Cells: Biology, Bioethics, and Applications http://stemcellbioethics.wikischolars.columbia.edu/Module+3+-+Cellular+Differentiation A concise starting point. Cellular differentiation Wikipedia https://en.wikipedia.org/wiki/Cellular_differentiation A very good overview of the subject. Ralston, A. and Shaw, K. (2008) Gene Expression Regulates Cell Differentiation. *Nature Education* 1, 127. http://www.nature.com/scitable/topicpage/Gene-Expression-Regulates-Cell-Differentiation-931 Paper exploring how gene expression patterns and their timing regulate cell differentiation.	1 hour	Unit 1 LO3 Unit 5 LO1

Title of suggested activity	Suggested activities	Suggested timings	Also related to
Gene expression	This section links strongly with Unit 5 Genetics. Learners need to appreciate that the changes that occur during differentiation are the result of regulated gene expression – and repression – in cells that are becoming specialised, and not to any loss of the cells' DNA. Gene expression is the process by which the information in the DNA is transcribed into messenger RNA, for protein synthesis (which is dealt with in detail in Unit 1 Science fundamentals). *Cell-extrinsic factors* involve cell signalling, with growth factors conveying information from one cell to another during the process. Cell-extrinsic factors include factors that modify chromatin (DNA and associated histone proteins); these factors are known as epigenetic as they don't affect the primary DNA sequence. This is fast becoming a major area of research. Module 3 – Cellular differentiation Stem Cells: Biology, Bioethics, and Applications http://stemcellbioethics.wikischolars.columbia.edu/Module+3+-+Cellular+Differentiation A concise starting point. Cellular differentiation Wikipedia https://en.wikipedia.org/wiki/Cellular_differentiation A very good overview of the subject. Ralston, A. and Shaw, K. (2008) Gene Expression Regulates Cell Differentiation. *Nature Education* 1, 127. http://www.nature.com/scitable/topicpage/Gene-Expression-Regulates-Cell-Differentiation-931 Paper exploring how gene expression patterns and their timing regulate cell differentiation.	4 hours	Unit 5 LO4

SUGGESTED ACTIVITIES

LO No:	5		
LO Title:	**Understand the potential of stem cells in medical therapies**		
Title of suggested activity	**Suggested activities**	**Suggested timings**	**Also related to**
Stem cells	From the previous activity, learners should be aware of the origin of stem cells. Begin by reinforcing a definition and the different types of stem cell. Learners should be able to distinguish between totipotent, pluripotent, multipotent and unipotent stem cells. It should be noted that in plants, cells capable of differentiation are called meristematic cells. The potential of stem cell therapies should be discussed, and a good starting point might be some contemporary areas: say, from newspaper articles on (sometimes purported) success and results of clinical trials. While more relevant in the next suggested activity, it might also be worth discussing any recent developments or legislation on growing embryos for research and potential therapy. It should be emphasised to learners that stem cell therapies are not new; the first successful bone marrow transplant, which transfers stem cells, was performed by doctors in 1968. Stem cell transplants have also been used (and still are) in the treatment of various cancers (leukaemia, lymphoma, myeloma) and following chemo- or radiotherapy. Some introductory websites, but new information will emerge continually: History of stem cell research UK Stem Cell Foundation (UKSCF) http://www.ukscf.org/about-stem-cell-research/history.html Gives a concise overview of the history of stem cell research. What are Stem Cells? University of Nebraska Medical Center http://www.unmc.edu/stemcells/stemcells/index.html Gives an excellent overview of stem cell basics. Yee, J. (2010) Turning Somatic Cells into Pluripotent Stem Cells. *Nature Education* 3: 25 http://www.nature.com/scitable/topicpage/turning-somatic-cells-into-pluripotent-stem-cells-14431451 There is a series of articles on cell biology and stem cells on the Scitable by Nature Education website: http://www.nature.com/scitable	4 hours	Unit 1 LO3

Title of suggested activity	Suggested activities	Suggested timings	Also related to
Stem cells (continued)	LifeMap Discovery as a Novel Stem Cell Database LifeMap Sciences http://discovery.lifemapsc.com/stem-cell-differentiation The central web page to an extensive range of stem cell technology topics. About stem cells; Cord blood stem cells: current uses and future challenges; Clinical trials and stem cell treatments. EuroStemCell http://www.eurostemcell.org/stem-cells http://www.eurostemcell.org/factsheet/cord-blood-stem-cells-current-uses-and-future-challenges http://www.eurostemcell.org/clinical-trials An extensive website giving latest information on stem cell technologies.  New Stem Cell State Azvolinsky, Anna http://www.the-scientist.com/?articles.view/articleNo/41643/title/New-Stem-Cell-State/ An example of one of the many articles on stem cells in *The Scientist* periodical.		

Title of suggested activity	Suggested activities	Suggested timings	Also related to
The uses, and potential uses, of stem cells in medicine	The role of stem cells in development has been covered in Learning Outcome 3. Here, stem cells should be discussed in a little more detail, with reference to researching and modelling cell function, including the study of how diseases develop and in drug testing, and the potential in terms of possible therapies to replace damaged or degenerate cells. The topic could be introduced using a range of newspaper or magazine articles, both positive and negative. These are some introductory websites, but new information will emerge continually: What are Stem Cells? University of Nebraska Medical Center http://www.unmc.edu/stemcells/stemcells/index.html Gives an excellent overview of stem cell basics. Yee, J. (2010) Turning Somatic Cells into Pluripotent Stem Cells. *Nature Education* 3: 25 http://www.nature.com/scitable/topicpage/turning-somatic-cells-into-pluripotent-stem-cells-14431451 There is a series of articles on cell biology and stem cells on the Scitable by Nature Education website: http://www.nature.com/scitable LifeMap Discovery as a Novel Stem Cell Database LifeMap Sciences http://discovery.lifemapsc.com/stem-cell-differentiation The central web page to an extensive range of stem cell technology topics. About stem cells; Cord blood stem cells: current uses and future challenges; Clinical trials and stem cell treatments EuroStemCell http://www.eurostemcell.org/stem-cells http://www.eurostemcell.org/factsheet/cord-blood-stem-cells-current-uses-and-future-challenges http://www.eurostemcell.org/clinical-trials An extensive website giving latest information on stem cell technologies. New Stem Cell State Azvolinsky, Anna http://www.the-scientist.com/?articles.view/articleNo/41643/title/New-Stem-Cell-State/ An example of one of the many articles on stem cells in *The Scientist* periodical.	1 hour	

Title of suggested activity	Suggested activities	Suggested timings	Also related to
Stem cell technologies	Learners could approach this Learning Outcome as a case study. The format could be an information document or website for the NHS. This is a rapidly expanding field. It could be approached by reviewing evidence to date, or focusing on one therapy that has been trialled. As well as this being a qualitative study, learners should also try to include data from clinical trials. The X-Cell Centers in Düsseldorf and Köln in Germany would also be a good discussion point. Their website presented very unconvincing data suggesting successful treatments. The centres have now closed down owing to patient deaths. Learners should also appreciate that regenerative medicine is just one focus of stem cell research. Learners might review the ability of different stem cells to differentiate into varying numbers of cell types, as well as some reported possible health issues, but should also consider moral and ethical issues in their justifications. Some factors o consider: • success of clinical trials • the respective potentials of adult, embryonic and other types of stem cells • the behaviour of stem cells after many generations in culture • the possible transfer of disease-causing agents during transplantation • therapeutic cloning techniques • risks vs. benefits • moral or ethical implications of creating embryos for research/generating stem cells – the embryo is destroyed in the process; at what point should an embryo be regarded as human? • objections by religious, pro-life and human rights groups • what is the potential efficacy, storage implications and cost implications of clinics storing 'umbilical cord blood stem cells'? What is the status of these stem cells – adult or embryonic? • does the acquisition of stem cell potency by somatic cells allay these fears? • clinical research is often carried out by private clinics rather than learned institutions and reliable data is often difficult to obtain • selling hope through unproven technologies; stem cell tourism • social aspects such as educating the public • could the techniques be used to clone humans? A brief overview, with some examples of resources, could be given to learners before they embark on a case study of an application that takes their interest. Some introductory websites are listed on the following page, but this is a rapidly developing field and new information will emerge continually.	4 hours	

Title of suggested activity	Suggested activities	Suggested timings	Also related to
Stem cell technologies (continued)	What are Stem Cells? University of Nebraska Medical Center http://www.unmc.edu/stemcells/stemcells/index.html Gives an excellent overview of stem cell basics. Yee, J. (2010) Turning Somatic Cells into Pluripotent Stem Cells. *Nature Education* 3: 25 http://www.nature.com/scitable/topicpage/turning-somatic-cells-into-pluripotent-stem-cells-14431451 There is a series of articles on cell biology and stem cells on the Scitable by Nature Education website: http://www.nature.com/scitable LifeMap Discovery as a Novel Stem Cell Database LifeMap Sciences http://discovery.lifemapsc.com/stem-cell-differentiation The central web page to an extensive range of stem cell technology topics. About stem cells; Cord blood stem cells: current uses and future challenges; Clinical trials and stem cell treatments EuroStemCell http://www.eurostemcell.org/stem-cells http://www.eurostemcell.org/factsheet/cord-blood-stem-cells-current-uses-and-future-challenges http://www.eurostemcell.org/clinical-trials An extensive website giving latest information on stem cell technologies.  New Stem Cell State Azvolinsky, Anna http://www.the-scientist.com/?articles.view/articleNo/41643/title/New-Stem-Cell-State/ An example of one of the many articles on stem cells in *The Scientist* periodical.		

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