Accredited

A LEVEL
Specification

BIOLOGY B
(ADVANCING BIOLOGY)

H422
For first assessment in 2017

ocr.org.uk/alevelbiologyb

Version 2 (December 2017)

OCR
Oxford Cambridge and RSA

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Contents

Introducing…

A Level Biology B (Advancing Biology) (from September 2015)

In this specification, learners study biology using a context-based approach. Ideas are introduced within relevant and interesting settings that help learners to anchor their conceptual knowledge of the range of biological topics required at GCE level. Practical skills are embedded within the specification and learners are expected to carry out practical work in preparation for a written examination that will specifically test these.

Meet the team

We have a dedicated team of people working on our A Level Biology qualifications.

Find out more about our Biology team at ocr.org.uk/scienceteam

If you need specialist advice, guidance or support, get in touch as follows:

- **01223 553998**
- scienceGCE@ocr.org.uk
- @OCRscience

Vertical black lines indicate a significant change to the previous printed version.

Teaching and learning resources

We recognise that the introduction of a new specification can bring challenges for implementation and teaching. Our aim is to help you at every stage and we're working hard to provide a practical package of support in close consultation with teachers and other experts, so we can help you to make the change.

Designed to support progression for all

Our resources are designed to provide you with a range of teaching activities and suggestions so you can select the best approach for your particular students. You are the experts on how your students learn and our aim is to support you in the best way we can.

We want to…

- Support you with a body of knowledge that grows throughout the lifetime of the specification.
- Provide you with a range of suggestions so you can select the best activity, approach or context for your particular students.
- Make it easier for you to explore and interact with our resource materials, in particular to develop your own schemes of work.
- Create an ongoing conversation so we can develop materials that work for you.

Plenty of useful resources

You'll have four main types of subject-specific teaching and learning resources at your fingertips:

- Delivery Guides
- Transition Guides
- Topic Exploration Packs
- Lesson Elements.

Along with subject-specific resources, you'll also have access to a selection of generic resources that focus on skills development and professional guidance for teachers.

Skills Guides – we've produced a set of Skills Guides that are not specific to Biology, but each covers a topic that could be relevant to a range of qualifications – for example, communication, legislation and research. Download the guides at ocr.org.uk/skillsguides.

Active Results – a free online results analysis service to help you review the performance of individual students or your whole school. It provides access to detailed results data, enabling more comprehensive analysis of results in order to give you a more accurate measurement of the achievements of your centre and individual students. For more details refer to ocr.org.uk/activeresults.

Professional development

Take advantage of our improved Professional Development Programme, designed with you in mind. Whether you want to come to face-to-face events, look at our new digital training or search for training materials, you can find what you're looking for all in one place at the CPD Hub.

An introduction to the new specifications

We'll be running events to help you get to grips with our A Level Biology B (Advancing Biology) qualification. These events are designed to help prepare you for first teaching and to support your delivery at every stage.

Watch out for details at cpdhub.ocr.org.uk.

To receive the latest information about the training we'll be offering, please register for A Level email updates at ocr.org.uk/updates.

1 Why choose an OCR A Level in Biology B (Advancing Biology)?

1a. Why choose an OCR qualification?

Choose OCR and you've got the reassurance that you're working with one of the UK's leading exam boards. Our new A Level in Biology B (Advancing Biology) course has been developed in consultation with teachers, employers and higher education to provide students with a qualification that's relevant to them and meets their needs.

We're part of the Cambridge Assessment Group, Europe's largest assessment agency and a department of the University of Cambridge. Cambridge Assessment plays a leading role in developing and delivering assessments throughout the world, operating in over 150 countries.

We work with a range of education providers, including schools, colleges, workplaces and other institutions in both the public and private sectors. Over 13,000 centres choose our A levels, GCSEs and vocational qualifications including Cambridge Nationals and Cambridge Technicals.

Our Specifications

We believe in developing specifications that help you bring the subject to life and inspire your students to achieve more.

We've created teacher-friendly specifications based on extensive research and engagement with the teaching community. They're designed to be straightforward and accessible so that you can tailor the delivery of the course to suit your needs. We aim to encourage learners to become responsible for their own learning, confident in discussing ideas, innovative and engaged.

We provide a range of support services designed to help you at every stage, from preparation through to the delivery of our specifications. This includes:

- A wide range of high-quality creative resources including:
  - delivery guides
  - transition guides
  - topic exploration packs
  - lesson elements
  - …and much more.
- Access to Subject Advisors to support you through the transition and throughout the lifetime of the specifications.
- CPD/Training for teachers to introduce the qualifications and prepare you for first teaching.
- Active Results – our free results analysis service to help you review the performance of individual students or whole schools.
- ExamBuilder – our free online past papers service that enables you to build your own test papers from past OCR exam questions.

All A level qualifications offered by OCR are accredited by Ofqual, the Regulator for qualifications offered in England. The accreditation number for OCR's A Level in Biology B (Advancing Biology) is QN: 601/4720/9.

1b. Why choose an OCR A Level in Biology B (Advancing Biology)?

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We appreciate that one size doesn't fit all so we offer two suites of qualifications in each science:

Biology A – Provides a flexible approach to teaching. The specification is divided into topics, each covering different key concepts of biology. Teaching of practical skills is integrated with the theoretical topics and they are assessed through the written papers. For A level only, the Practical Endorsement will also support the development of practical skills.

Biology B (Advancing Biology) – Learners study biology using a context based approach. Ideas are introduced within relevant and interesting settings which help learners to anchor their conceptual knowledge of the range of biological topics required at GCE level. Practical skills are embedded within the specification and learners are expected to carry out practical work in preparation for a written examination that will specifically test these skills.

All of our specifications have been developed with subject and teaching experts. We have worked in close consultation with teachers and representatives from Higher Education (HE) with the aim of including up-to-date relevant content within a framework that is interesting to teach and administer within all centres (large and small).

Biology B (Advancing Biology) is a new course for OCR.

It has been designed as an alternative approach to OCR Biology A. Advancing Biology, like OCRs other 'B' specifications, is designed in such a way as to give learners relevant and interesting contexts in which to set their study of complex biological ideas. For example, learners consider cell structure and function in the context of the blood and the cells found in it and photosynthesis in the context of food production and management of the environment.

We've based the redevelopment of our A level sciences on an understanding of what works well in centres large and small. We've undertaken a significant amount of consultation through our science forums (which include representatives from learned societies, HE, teaching and industry) and through focus groups with teachers. Our papers and specifications have been trialled in centres during development to make sure they work well for all centres and learners.

The content changes are an evolution of our legacy offering and will be familiar to centres already following our courses, but also clear and logically laid out for centres new to OCR, with assessment models that are straightforward to administer. We have worked closely with teachers and HE representatives to provide high quality support materials to guide you through the new qualifications.

Aims and learning outcomes

OCR's A Level in Biology B (Advancing Biology) specification aims to encourage learners to:

- develop essential knowledge and understanding of different areas of the subject and how they relate to each other
- develop and demonstrate a deep appreciation of the skills, knowledge and understanding of scientific methods
- develop competence and confidence in a variety of practical, mathematical and problem solving skills
- develop their interest in and enthusiasm for the subject, including developing an interest in further study and careers associated with the subject
- understand how society makes decisions about scientific issues and how the sciences contribute to the success of the economy and society (as exemplified in 'How Science Works' (HSW)).

1c. What are the key features of this specification?

Our Biology B (Advancing Biology) specification has been designed so learners study biology using an engaging, context-based approach. The specification:

- is laid out clearly in a series of teaching modules with Additional guidance added where required to clarify assessment requirements. Ideas are introduced within relevant and contemporary settings that help students to anchor their conceptual knowledge of the range of biological topics required at A level
- is co-teachable with the AS level
- embeds practical requirements within the teaching modules
- identifies Practical Endorsement requirements and how these can be integrated into teaching of content (see Section 5)
- exemplifies the mathematical requirements of the course (see Section 5)
- highlights opportunities for the introduction of key mathematical requirements (see Section 5 and the additional guidance column for each module) into your teaching
- identifies, within the Additional guidance how the skills, knowledge and understanding of How Science Works (HSW) can be incorporated within teaching.

Teacher support

The extensive support offered alongside this specification includes:

- **delivery guides** – providing information on assessed content, the associated conceptual development and contextual approaches to delivery
- **transition guides** – identifying the levels of demand and progression for different key stages for a particular topic and going on to provide links to high quality resources and 'checkpoint tasks' to assist teachers in identifying learners 'ready for progression'
- **lesson elements** – written by experts, providing all the materials necessary to deliver creative classroom activities
- **Active Results** (see Section 1a)
- **ExamBuilder** (see Section 1a)
- **mock examinations service** – a free service offering a practice question paper and mark scheme (downloadable from a secure location).

Along with:

- Subject Advisors within the OCR science team to help with course queries
- teacher training
- *Science Spotlight* (our termly newsletter)
- OCR Science community
- a consultancy service (to advise on Practical Endorsement requirements)
- Practical Skills Handbook
- Maths Skills Handbook.

1d. How do I find out more information?

Whether new to our specifications, or continuing on from our legacy offerings, you can find more information on our webpages at: www.ocr.org.uk

Visit our subject pages to find out more about the assessment package and resources available to support your teaching. The science team also release a termly newsletter *Science Spotlight*.

You can contact the Science Subject Advisors: ScienceGCE@ocr.org.uk, 01223 553998.

Join our Science community: http://social.ocr.org.uk/

Check what CPD events are available: www.cpdhub.ocr.org.uk

Follow us on Twitter: @ocr_science

2 The specification overview

2a. Overview of A Level in Biology B (Advancing Biology) (H422)

Learners must complete all components (01, 02, 03 and 04) to be awarded the OCR A Level in Biology B.

Content Overview	Assessment Overview	
Content is split into five teaching modules: • Module 1 – Development of practical skills in biology • Module 2 – Cells, chemicals for life, transport and gas exchange • Module 3 – Cell division, development and disease control • Module 4 – Energy, reproduction and populations • Module 5 – Genetics, control and homeostasis Components 01, 02 and 03 can assess content from all modules (1–5).	Fundamentals of biology (01) 110 marks 2 hour 15 minutes written paper	**41%** of total A level
	Scientific literacy in biology (02) 100 marks 2 hour 15 minutes written paper	**37%** of total A level
	Practical skills in biology (03) 60 marks 1 hour 30 minutes written paper	**22%** of total A level
	Practical Endorsement in biology (04) (non exam assessment)	Reported separately (see Section 5g)

All components include synoptic assessment.

2b. Content of A Level in Biology B (Advancing Biology) (H422)

The A Level in Biology B (Advancing Biology) specification content is divided into five teaching modules and each module is further divided into key topics. Each module is introduced with a summary of the biology it contains. The assessable content is then divided into two columns: **Learning outcomes** and **Additional guidance**.

The Learning outcomes may all be assessed in the examination (with the exception of some of the skills in module **1.2** which will be assessed directly through the Practical Endorsement). The Additional guidance column is included to provide further advice on delivery and the expected skills required from learners.

References to HSW (Section 5) are included in the guidance to highlight opportunities to encourage a wider understanding of science.

The mathematical requirements in Section 5 are also referenced by the prefix M to link the mathematical skills required for A Level Biology to the areas of science content where those mathematical skills could be linked to learning.

The specification has been designed to be co-teachable with the standalone AS Level in Biology B (Advancing Biology) qualification. The first three modules comprise the AS Level in Biology B (Advancing Biology) course and learners studying the A level continue with the content of modules 4 and 5, and with the Practical Endorsement skills from module 1.2 in year 13.

A summary of the content for the A level course is as follows:

Module 1 – Development of practical skills in biology

1.1 Practical skills assessed in a written examination

1.2 Practical skills are assessed in the practical endorsement

Module 2 – Cells, chemicals for life, transport and gas exchange

2.1.1 Cells and microscopy
2.1.2 Water and its importance in plants and animals
2.1.3 Proteins and enzymes
2.1.4 Nucleic acids
2.2.1 The heart and monitoring heart function
2.2.2 Transport systems in mammals
2.2.3 Gas exchange in mammals and plants
2.2.4 Transport systems in plants

Module 3 – Cell division, development and disease control

3.1.1 The developing cell: cell division and cell differentiation
3.1.2 The developing individual: meiosis, growth and development
3.1.3 The development of species: evolution and classification
3.2.1 Pathogenic microorganisms
3.2.2 The immune system
3.2.3 Controlling communicable diseases
3.3.1 The cellular basis of cancer and treatment
3.3.2 Respiratory diseases and treatment

Module 4 – Energy, reproduction and populations

4.1.1 Cellular respiration
4.1.2 Metabolism and exercise
4.2.1 Fertility and assisted reproduction
4.2.2 The effects of ageing on the reproductive system
4.3.1 Photosynthesis, food production and management of the environment
4.3.2 The impact of population increase
4.4.1 Plant reproduction

Module 5 – Genetics, control and homeostasis

5.1.1 Patterns of inheritance
5.1.2 Population genetics and epigenetics
5.1.3 Gene technologies
5.2.1 The nervous system and the identification and consequences of damage
5.2.2 Monitoring visual function
5.2.3 The effect of ageing on the nervous system
5.3.1 The principles and importance of homeostasis
5.3.2 The hormonal control of blood glucose and the management of diabetes
5.3.3 Kidney functions and malfunctions

Assessment of practical skills and the Practical Endorsement

Module 1 of the specification content relates to the practical skills learners are expected to gain throughout the course, which are assessed throughout the written examinations and also through the Practical Endorsement (see Section 5).

Practical activities are embedded within the learning outcomes of the course to encourage practical activities in the classroom which contribute to the achievement of the Practical Endorsement (Section 5) as well as enhancing learners' understanding of biological theory and practical skills.

Opportunities for carrying out activities that could count towards the Practical Endorsement are indicated throughout the specification. These are shown in the Additional guidance column as **PAG1** to **PAG11** (Practical Activity Group, see Section 5). There are a wide variety of opportunities to assess **PAG12** throughout the qualification.

2c. Content of modules 1 to 5

Module 1: Development of practical skills in biology

The development of practical skills is a fundamental and integral aspect of the study of any scientific subject. These skills not only enhance learners' understanding of the subject but also serve as a suitable preparation for the demands of studying biology at a higher level.

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1.1 Practical skills assessed in a written examination

Practical skills are embedded throughout all sections of this specification.

Learners will be required to develop a range of practical skills throughout their course in preparation for the written examinations.

1.1.1 Planning

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	experimental design, including to solve problems set in a practical context	Including selection of suitable apparatus, equipment and techniques for the proposed experiment. Learners should be able to apply scientific knowledge based on the content of the specification to the practical context. HSW3
(b)	identification of variables that must be controlled, where appropriate	*M0.1*
(c)	evaluation that an experimental method is appropriate to meet the expected outcomes.	HSW6

1.1.2 Implementing

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	how to use a wide range of practical apparatus and techniques correctly	As outlined in the content of the specification and the skills required for the Practical Endorsement. HSW4
(b)	appropriate units for measurements	*M0.1*
(c)	presenting observations and data in an appropriate format.	HSW8

1.1.3 Analysis

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	processing, analysing and interpreting qualitative and quantitative experimental results	Including reaching valid conclusions, where appropriate. HSW5
(b)	use of appropriate mathematical skills for analysis of quantitative data	Refer to Section 5 for a list of mathematical skills that learners should have acquired competence in as part of their course. HSW3
(c)	appropriate use of significant figures	*M1.1*
(d)	plotting and interpreting suitable graphs from experimental results, including:	
	(i) selection and labelling of axes with appropriate scales, quantities and units	*M3.2*
	(ii) measurement of gradients and intercepts.	*M3.3, M3.4, M3.5*

1.1.4 Evaluation

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	how to evaluate results and draw conclusions	HSW6
(b)	the identification of anomalies in experimental measurements	
(c)	the limitations in experimental procedures	
(d)	precision and accuracy of measurements and data, including margins of error, percentage errors and uncertainties in apparatus	*M1.11*
(e)	the refining of experimental design by suggestion of improvements to the procedures and apparatus.	HSW3

1.2 Practical skills assessed in the practical endorsement

A range of practical experiences are a vital part of a learners learning as part of this course.

Learners should develop and practise a wide range of practical skills throughout the course as preparation for the Practical Endorsement, as well as for the written examinations.

The experiments and skills required for the Practical Endorsement will allow learners to develop and practice their practical skills, preparing learners for the written examinations.

Please refer to Section 5 (the Practical Endorsement) of this specification to see the list of practical experiences all learners should cover during their course. Further advice and guidance on the Practical Endorsement can be found in the Practical Skills Handbook.

1.2.1 Practical skills

	Learning outcomes	Additional guidance
	Practical work carried out throughout the course will enable learners to develop the following skills:	
	Independent thinking	
(a)	apply investigative approaches and methods to practical work	Including how to solve problems in a practical context. HSW3
	Use and application of scientific methods and practices	
(b)	safely and correctly use a range of practical equipment and materials	See Section 5. Including identification of potential hazards. Learners should understand how to minimise the risks involved. HSW4
(c)	follow written instructions	
(d)	make and record observations/measurements	HSW8
(e)	keep appropriate records of experimental activities	See Section 5.
(f)	present information and data in a scientific way	HSW8
(g)	use appropriate software and tools to process data, carry out research and report findings	*M3.1* HSW3

Research and referencing

(h)	use online and offline research skills including websites, textbooks and other printed scientific sources of information	
(i)	correctly cite sources of information	The Practical Skills Handbook provides guidance on appropriate methods for citing information.

Instruments and equipment

(j)	use a wide range of experimental and practical instruments, equipment and techniques appropriate to the knowledge and understanding included in the specification.	See Section 5. HSW4

1.2.2 Use of apparatus and techniques

	Learning outcomes	Additional guidance
	*Through use of the apparatus and techniques listed below, and a minimum of 12 assessed practicals (see Section 5g), learners should be able to demonstrate all of the practical skills listed within 1.2.1 and CPAC (Section 5g, **Table 2**) as exemplified through:*	
(a)	use of appropriate apparatus to record a range of quantitative measurements (to include mass, time, volume, temperature, length and pH)	HSW4
(b)	use of appropriate instrumentation to record quantitative measurements, such as a colorimeter or potometer	HSW4
(c)	use of laboratory glassware apparatus for a variety of experimental techniques to include serial dilutions	HSW4
(d)	use of a light microscope at high power and low power, including use of a graticule	HSW4
(e)	production of scientific drawings from observations with annotations	HSW8
(f)	use of qualitative reagents to identify biological molecules	HSW4
(g)	separation of biological compounds using thin layer/paper chromatography or electrophoresis	HSW4
(h)	safe and ethical use of organisms to measure: **(i)** plant or animal responses **(ii)** physiological functions	HSW4, HSW10
(i)	use of microbiological aseptic techniques, including the use of agar plates and broth	HSW4
(j)	safe use of instruments for dissection of an animal or plant organ	HSW4
(k)	use of sampling techniques in fieldwork	HSW4
(l)	use of ICT such as computer modelling, or a data logger to collect data, or use of software to process data	HSW3, HSW4

Module 2: Cells, chemicals for life, transport and gas exchange

2.1 Cells and chemicals for life

This section provides learners with a knowledge and understanding of how the use of microscopy allowed the development of the cell theory, which is a unifying concept in biology. It also focuses on the importance of microscopy in investigating the structure of eukaryotic and prokaryotic cells. Learners will also gain an insight into some of the advanced microscopic techniques used by cell biologists today.

The structure of animal cells is studied in the context of the histology of mammalian blood as revealed by light microscopy and is contrasted with the structure of typical plant cells.

An understanding of the importance of enzyme-catalysed reactions is illustrated by the biochemical processes that prevent excessive blood loss, and learners investigate how first-aid and medical intervention can assist the body's natural mechanisms for preventing blood loss.

In addition to enzymes, this section covers the structures and functions of other biologically important molecules in animals and plants, including DNA, natural polymers, and the different mechanisms for transporting molecules into and out of living cells. Learners gain an appreciation of the importance of water in living organisms and as the essential medium in which transport and exchange takes place.

Learners are expected to apply knowledge, understanding and other skills gained in this section to new situations and/or to solve related problems.

2.1.1 Cells and microscopy

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	**(i)** the importance of microscopy in the development of the cell theory as a unifying concept in biology and the investigation of cell structure	To include the use of the light microscope, transmission and scanning electron microscopes and recent developments such as the confocal scanning microscope.
	(ii) the preparation of blood smears (films) for use in light microscopy	To include how blood smears are made and the interpretation of stained material. Practical work to be carried out in accordance with current CLEAPSS® guidelines. Also see Section 5. **PAG1** HSW4, HSW6
(b)	the procedure for differential staining	To include the use of Leishman's stain to identify leucocytes in blood smears. HSW4, HSW6

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(c)	**(i)**	the structure of animal cells as illustrated by a range of blood cells and components as revealed by the light microscope	To include red blood cells (erythrocytes), platelets, neutrophils, lymphocytes and monocytes as specialised cells with particular functions related to their structures.
	(ii)	the observation, drawing and annotation of cells in a blood smear as observed using the light microscope	**PAG1**
(d)		the linear dimension of cells and the use and manipulation of the magnification formula $\text{magnification} = \frac{\text{image size}}{\text{actual size}}$ (of object)	*M1.8* **PAG1**
(e)		practical investigations using a haemocytometer to determine cell counts	To determine the mean numbers of erythrocytes and convert to a concentration (to include details of dilutions and calculations). *M0.1, M0.2, M0.3, M1.5, M1.10, M4.1* **PAG1** HSW3, HSW4, HSW5, HSW6
(f)		the principles and use of flow cytometry in blood analysis	To include the use of fluorescent labels. Details of the use of different lasers is not required. HSW3, HSW8
(g)		the ultrastructure of a typical eukaryotic animal cell, such as a leucocyte, as revealed by an electron microscope	To include the structure and function of the following: plasma membrane, Golgi apparatus, rough endoplasmic reticulum (RER) and smooth endoplasmic reticulum (SER), ribosomes, lysosomes, vesicles, mitochondria, cytoskeleton, centrioles. nucleus and nucleolus. HSW8 *M1.8*
(h)	**(i)**	the ultrastructure of a typical eukaryotic plant cell such as a palisade mesophyll cell and a prokaryotic cell, as revealed by an electron microscope	To include the structure and function of chloroplasts, large vacuole, tonoplast and the cell wall in plant cells, circular DNA, plasmids, mesosome, pili and flagella in prokaryotic cells. HSW8
	(ii)	the similarities and differences between the structure of eukaryotic plant and animal cells, and between eukaryotic and prokaryotic cells	

(i)	practical investigations using a graticule and stage micrometer to calculate and measure linear dimensions of cells	To include the calibration of an eyepiece graticule using a stage micrometer, calculating the area of the field of view and measuring the sizes of organs, tissues, cells and organelles and calculating their magnification. *M0.1, M0.2, M1.1, M1.2, M1.8, M2.2, M4.1* **PAG1** HSW3, HSW4, HSW8
(j)	how the plasma membrane is composed of modified lipids and how the structure of triglycerides and phospholipids is related to their functions	To include reference to fatty acids, glycerol, phosphate groups, ester bonds and hydrophobic/ hydrophilic properties.
(k)	the fluid mosaic model of the typical plasma membrane	To include the location and function of phospholipids, intrinsic proteins, extrinsic proteins, cholesterol, glycolipids and glycoproteins.
(l)	the movement of molecules across plasma membranes	To include diffusion and facilitated diffusion as passive methods of transport across membranes **AND** active transport, endocytosis and exocytosis as processes requiring ATP as an immediate source of energy. HSW8
(m)	practical investigation(s) into factors affecting diffusion rates in cells	To include the use of model cells and tissues such as beetroot. *M0.1, M0.2, M1.1, M1.2, M3.1, M3.2, M3.3, M3.5, M3.6* **PAG8** HSW1, HSW2, HSW3, HSW4, HSW5, HSW6
(n)	the roles of membranes within and at the surface of cells	
(o)	the interrelationship between the organelles involved in the production and secretion of proteins.	To include the role of the cytoskeleton and motor proteins, the nucleus, ribosomes, RER, Golgi and vesicles (no details of transcription and translation are required at this stage). HSW8

2.1.2 Water and its importance in plants and animals

		Learning outcomes	Additional guidance
		Learners should be able to demonstrate and apply their knowledge and understanding of	
(a)		the properties of water	To include the polar nature of the water molecule, hydrogen bonding and the role of water as a solvent.
(b)	**(i)**	the importance of water as a major constituent of cytoplasm, intracellular and extracellular fluids, and as the essential transport medium in plants and animals	To include the transpiration stream, cell sap and the maintenance of turgor in plants, and plasma, serum, tissue fluid, lymph and urine in mammals. *M0.1, M0.2, M0.3, M1.1, M1.2, M1.6, M3.1* HSW5, HSW6
	(ii)	analysis of secondary data on the composition of mammalian body fluids and plant extracts to illustrate the role of water as a solvent	To include solutes (sugars, proteins), electrolytes (hydrogen ions, H^+, potassium ions, K^+, sodium ions, Na^+, chloride ions, Cl^-, hydrogencarbonate ions, HCO_3^-, magnesium ions, Mg^{2+}).
(c)	**(i)**	how sugar and protein molecules can be detected and measured in body fluids and plant extracts	To include the use of reagent test strips and biosensors to detect and measure the concentration of sugars and proteins. *M0.1, M0.2, M0.3, M1.1, M1.2, M1.3, M1.6, M3.1, M3.2* **PAG5, PAG9** HSW3, HSW4, HSW5, HSW6
	(ii)	the methodology and interpretation of the results of the Biuret test, Benedict's test and colorimetry	
(d)		the importance of hydrolysis and condensation of biological molecules in cell metabolism	To include the concept of monomers and polymers in a range of biological molecules.
(e)		the structure of the ring form of α-glucose as an example of a simple monosaccharide, and lactose as a disaccharide	To include the concept of organic molecules as generally containing carbon atoms and a number of additional elements.
(f)	**(i)**	the formation of polysaccharides by condensation	To include glycogen and starch (amylose and amylopectin) **AND** the formation of 1,4- and 1,6-glycosidic bonds and reference to the significance of branching on solubility.
	(ii)	a test for the identification and measurement of starch	To include the qualitative test for starch using iodine and colorimetry. **PAG5, PAG9**

(g)	osmosis, in terms of the movement of water down a water potential gradient	To include the effect of solutes and electrolytes on the water potential of plant cells and animal cells and on solutions within organisms e.g. body fluids, plant sap. *M0.3, M1.1, M1.2, M1.3, M3.1, M3.2, M3.4*
(h)	practical investigation(s) into factors affecting osmosis in plant and animal cells.	*M0.3, M1.1, M1.2, M1.3, M3.1, M3.2, M3.4* **PAG8** HSW3, HSW4, HSW5, HSW6

2.1.3 Proteins and enzymes

		Learning outcomes	Additional guidance
		Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	**(i)**	the basic structure of an amino acid and the formation of peptide bonds	
	(ii)	the use of chromatography in the separation and identification of amino acids	To include calculation of retention (*Rf*) values. $Rf = \frac{distance\ moved\ by\ the\ solute}{distance\ moved\ by\ the\ solvent}$ Practical work to be carried out in accordance with current CLEAPSS® guidelines with regards to the risks associated with the use of ninhydrin. Also see Section 5f. **PAG6**
(b)		the molecular structure of globular proteins as illustrated by the structure of enzymes and haemoglobin	To include primary, secondary and tertiary structure in relation to enzymes, and quaternary structure and prosthetic groups in relation to haemoglobin.
(c)		how the structure of globular proteins enable enzyme molecules to catalyse specific metabolic reactions	To include the role of tertiary structure in the specificity of the active site, the formation of enzyme substrate complexes and the lowering of the activation energy.
(d)	**(i)**	the factors affecting the rate of enzyme-catalysed reactions	*M0.1, M1.2, M1.3, M1.11, M3.1, M3.2, M3.3, M3.5, M3.6* **PAG4** HSW3, HSW4, HSW5, HSW6, HSW8
	(ii)	practical investigations into the factors affecting the rate of enzyme-catalysed reactions	
(e)	**(i)**	the role of proteins in blood clotting, and blood clotting as an enzyme-controlled process	To include the role of platelets, damaged tissue, thromboplastin, calcium ions, prothrombin, thrombin, fibrinogen and fibrin.
	(ii)	the first-aid procedure to assist the blood clotting process and prevent excessive blood loss	HSW10, HSW11, HSW12
(f)		the use of enzymes and inhibitors in medical diagnosis and treatment	To include diagnostic enzymes (e.g. blood amylase and LDH) and enzymes and inhibitors used in medical treatment (e.g. streptokinase, aspirin and warfarin).
(g)		the donation of blood, and the types and uses of stored blood products.	To include blood groups and a consideration of the other issues affecting blood donation **AND** the collection and use of whole blood, leuco-depleted blood, packed red cells, platelets, clotting factors and plasma. HSW9, HSW10, HSW11, HSW12

2.1.4 Nucleic acids

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	the structure of a nucleotide as the monomer from which nucleic acids are made	To include the differences between RNA and DNA nucleotides, the identification of the purines and pyrimidines, the type of pentose sugar and the formation of phosphodiester bonds (the sugar phosphate 'backbone').
(b)	the structure of adenosine di-phosphate (ADP) and adenosine tri-phosphate (ATP) as phosphorylated nucleotides	
(c) **(i)**	the structure of the DNA molecule, including a review of the evidence for complementary base pairing (Chargaff's rules)	*M0.3*
(ii)	practical investigation into the purification of DNA by precipitation	HSW3, HSW7
(d)	semi-conservative DNA replication	To include the roles of the enzymes helicase and DNA polymerase, the importance of replication in conserving genetic information with accuracy and the occurrence of random, spontaneous mutations.
(e)	the nature of the genetic code	To include reference to the triplet, non-overlapping, degenerate and universal nature of the code and how a gene determines the structure of proteins including enzymes by ordering the sequence of amino acids in a polypeptide.
(f)	the structure of RNA (ribonucleic acid) and how it differs from that of DNA	
(g)	transcription and translation of genes resulting in the synthesis of polypeptides.	To include the role of RNA polymerase, messenger (m)RNA, transfer (t)RNA and ribosomal (r)RNA (details of post transcriptional modification are not required).

2.2 Transport and gas exchange systems

This section provides learners with a knowledge and understanding of the structure and functions of the transport and gas exchange systems in mammals and multicellular terrestrial plants.

Learners will gain an appreciation of the need for mass transport systems and the significance of the surface area to volume ratio in multicellular organisms. The mass flow of materials within mammals and the exchange of molecules are studied in the context of the need to maintain a high metabolic rate.

Technological advances enable the activity of the heart, circulation and gas exchange systems to be monitored. Learners will be able to apply their knowledge of physiology to the interpretation of data on vital measurements of heart function, blood pressure and pulmonary ventilation. The importance of timely emergency treatment in both cardiac and respiratory arrest is also studied.

In this section, learners gain an understanding of the transport systems of terrestrial plants. In crop plants, the sites where organic molecules are stored – the harvestable parts of the plant – are often different to the sites where these molecules are produced – the leaves. This means that these molecules must be moved around the plant as required. The movement of water through a plant is, however, mainly due to physical mechanisms and processes. Learners will investigate the transport systems of multicellular plants and the different tissues involved. They will gain an appreciation of how the distribution of these tissues varies between different types of plants and that this distribution is diagnostic of the type of crop plant (broad-leaved or cereal) and the structural part of the plant (stem or root).

Learners are expected to apply knowledge, understanding and other skills gained in this section to new situations and/or to solve related problems.

2.2.1 The heart and monitoring heart function

		Learning outcomes	Additional guidance
		Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)		the need for a mass transport system in mammals	$Ratio = \frac{Surface\ Area}{Volume}$ To include references to a high basal metabolic rate, being multicellular and the significance of surface area to volume ratio. *M0.3, M4.1*
(b)	**(i)**	the internal and external structure of the mammalian heart	**PAG2** HSW3, HSW4, HSW5, HSW6, HSW8
	(ii)	the examination, dissection and drawing of the mammalian heart	
(c)		the cardiac cycle	To include the role of the valves and the pressure changes occurring in the heart and associated vessels.
(d)		how heart action is initiated and co-ordinated	To include the roles of the sino-atrial node (SAN), atrio-ventricular node (AVN), purkyne tissue and the myogenic nature of cardiac muscle (no detail on hormonal and nervous control is required at AS level but at A level this is covered in 5.3.1(b)).

(e)	practical investigation(s) into the factors affecting heart rate	To include the effect of exercise. *M0.1, M0.4, M1.2, M1.3, M1.11, M2.3, M2.4, M3.1, M3.2* **PAG10, PAG11** HSW3, HSW4, HSW5, HSW6
(f)	the effect of heart rate on cardiac output	To include calculations based on heart rate and stroke volume. $cardiac\ output = heart\ rate \times stroke\ volume$ *M0.1, M0.4, M1.2, M1.3, M1.11, M2.3, M2.4, M3.1, M3.2* **PAG10, PAG11** HSW3, HSW4, HSW5, HSW6
(g)	the measurement and interpretation of pulse rate, to include the generation of primary data and the use of secondary data	*M0.1, M0.4, M1.2, M1.3, M1.10, M1.11, M3.1, M3.2* **PAG10, PAG11** HSW3, HSW4, HSW5, HSW6
(h)	the use and interpretation of an electrocardiogram (ECG)	To include tachycardia, bradycardia, S-T elevation and fibrillation. *M3.1* HSW3, HSW5
(i)	the emergency treatment given to a person suffering a suspected heart attack or cardiac arrest.	To include the first-aid treatment for a heart attack and cardiac arrest **AND** the use of a defibrillator following cardiac arrest.

2.2.2 Transport systems in mammals

		Learning outcomes	Additional guidance
		Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)		the importance of the closed double circulatory system	To include reference to blood pressure in systemic and pulmonary systems.
(b)	**(i)**	the structure and functions of arteries, arterioles, capillaries, venules and veins	HSW4, HSW5, HSW6
	(ii)	transverse sections of arteries, veins and capillaries as observed using a light microscope	Prepared slides or photomicrographs may be examined to show the structural differences between these vessels.
(c)		the formation and importance of tissue fluid	To include references to HP (hydrostatic pressure) and OP (oncotic pressure or colloidal osmotic pressure).
(d)	**(i)**	the use of a sphygmomanometer to measure systolic and diastolic blood pressure	To include reference to both manual and electronic measuring.
	(ii)	comparisons of blood pressure readings	HSW3, HSW4, HSW5, HSW6
(e)		the interpretation of systolic and diastolic blood pressure measurements	To include hypertension and hypotension and their possible consequences.

2.2.3 Gas exchange in mammals and plants

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	**(i)** the relationships between cells, tissues and organs in the mammalian gas exchange system	To include the appearance and the histology of squamous epithelial cells in the alveoli, ciliated epithelial tissue, smooth muscle, cartilage and elastic fibres.
	(ii) observations of tissues of the gas exchange system using microscopy	**PAG1** HSW4, HSW5, HSW6
(b)	the process of gas exchange in the alveoli	To include the roles of ventilation, epithelial tissue, smooth muscle, cartilage, elastic fibres, blood capillaries and surfactant in the establishment and maintenance of concentration gradients.
(c)	the parameters affecting pulmonary ventilation	To include consideration of tidal volume, breathing rate, vital capacity, residual volume, PEFR and FEV_1 (no detail of the use of a spirometer is required). **PAG10** *M0.1, M2.2, M2.3, M2.4*
(d)	how expired air resuscitation can be carried out on adults, children and babies in cases of respiratory arrest	To include reference to both manual and electronic methods. HSW3, HSW4, HSW5, HSW6
(e)	the process of gas exchange in terrestrial plants.	To include the diffusion of gases between the atmosphere and intercellular spaces of leaves via stomata and through the lenticels of stems.
(f)	**(i)** the structure of stomata, their opening and closing	To include reference to changes in turgor and water potential of guard cells and the need for ATP.
	(ii) the microscopic appearance of stomata	To include the appearance of stomata in the leaves of different terrestrial plants. **PAG1**

2.2.4 Transport systems in plants

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	the need for transport systems in multicellular plants	To include references to size, variations in metabolic rate and the significance of surface area to volume ratio.
(b)	the structure, function and location of vascular tissue in roots, stems and leaves	To include xylem vessels, sieve tube elements and companion cells in the roots, stems and leaves of monocotyledonous crop plants (cereals) and dicotyledonous crop plants (broad-leaved crops e.g. carrots, potatoes).

(c)	**(i)**	the observation, drawing and annotation of stained sections of plant tissues using a light microscope	*M0.1, M0.2, M1.1, M1.2, M1.8, M2.1* **PAG1** HSW2, HSW3, HSW4, HSW5, HSW8
	(ii)	the longitudinal and transverse dissection and examination of plant organs to demonstrate the position and structure of vascular tissue	**PAG2** HSW2, HSW3, HSW4, HSW5, HSW8
(d)		the entry and transport of water in terrestrial plants	To include details of the pathways taken by water **AND** the mechanisms of movement, including adhesion, cohesion and the transpiration stream, in terms of water potential. HSW2, HSW8
(e)	**(i)**	the process of transpiration and the environmental factors that affect the transpiration rate	To include an appreciation that transpiration occurs due to physical processes linked to gaseous exchange in leaves.
	(ii)	practical investigations to estimate transpiration rates	*M0.1, M0.2, M1.1, M1.2, M1.3, M1.6, M1.11, M3.1, M3.2, M3.3, M3.5, M3.6, M4.1* **PAG5** HSW2, HSW3, HSW4, HSW5, HSW6, HSW8
(f)		the mechanism of translocation.	To include translocation in the phloem as an energy-requiring process transporting assimilates, especially sucrose, between sources (e.g. leaves) and harvestable sinks (e.g. roots, stems and seeds) **AND** details of active loading at the source and removal at the sink

Module 3: Cell division, development and disease control

3.1 Cell division and development

This section provides learners with knowledge and understanding of biological development on three levels: cell division by mitosis (where genetic information is copied and passed to daughter cells) cell differentiation, cell division by meiosis and fetal development, and the evolutionary development of species.

Scientific research has highlighted the role of apoptosis during the life cycle of a multicellular organism. The importance of both mitosis and apoptosis is considered in relation to fetal growth and development, as well as an appreciation that these processes are affected by environmental factors. Knowledge of recent advancements in stem cell technology and its potential applications further enhance learners' understanding of these fundamental cellular processes.

Meiosis is also studied as a process that promotes genetic biodiversity and variation. The potential for change and the development of new species by the action of natural selection on genetic variation is seen as an essential part of the process of evolution. Learners will also gain an understanding that the variety of life, both past and present, is extensive, but the biochemical basis of life is similar for all living things as well as of the link between natural selection and the adaptations of living organisms to their environments.

Learners are expected to apply knowledge, understanding and other skills gained in this section to new situations and/or to solve related problems.

3.1.1 The developing cell: cell division and cell differentiation

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	the cell cycle	To include the processes taking place during interphase (G_1,S and G_2), mitosis and cytokinesis, leading to genetically identical daughter cells.
(b) **(i)**	the changes that take place in the nuclei and cells of animals and plants during mitosis	To include the changes in the nuclear envelope and the behaviour of the centrioles, spindle fibres, centromere, chromatids and chromosomes, and the formation of the cell plate in plant cells.
(ii)	the microscopic appearance of cells undergoing mitosis	To include the examination and drawing of stained sections or squashes of plant tissue and the identification of the stages observed. **PAG1** HSW4, HSW5, HSW6
(c)	the principal stages and features of apoptosis	To include cell shrinkage, nuclear condensation (pyknosis), blebs, nuclear fragmentation (karyorrhexis), the roles of phosphatidylserine and macrophages.
(d)	the importance of apoptosis and mitosis in growth and repair	To include examples of the roles of apoptosis in cell deletion and mitosis in cell addition.

(e)	**(i)**	the differentiation of stem cells into specialised cells	To include an appreciation of the differences between totipotent, pluripotent and multipotent stem cells, and the differentiation of bone marrow stem cells into specialised blood cells.
	(ii)	current applications and uses of stem cells.	To include the use of bone marrow stem cells.

3.1.2 The developing individual: meiosis, growth and development

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	the significance of meiosis in sexual reproduction and the production of haploid gametes in plants and animals	To include the importance of meiosis in maintaining the chromosome number at fertilisation and between generations.
(b)	the stages of meiosis in plant and animal cells	To include the use of diagrams to describe interphase, prophase 1, metaphase 1, anaphase 1, telophase 1, prophase 2, metaphase 2, anaphase 2, telophase 2 (no details of the names of the stages within prophase 1 are required). **PAG1**
(c)	how meiosis produces daughter cells that are genetically different	To include the importance of chiasma formation, crossing over, independent assortment of chromosomes (metaphase 1) and chromatids (metaphase 2), in producing genetic variation.
(d)	the programme of antenatal care in the United Kingdom	To include pre-conceptual care and post-conceptual care.
(e)	the dietary changes recommended during pregnancy	To include the roles of protein, calcium, iron, vitamin A, vitamin C and folic acid **AND** the reasons for changes in DRV recommendations of these nutrients and energy during pregnancy.
(f)	the effects of alcohol consumption and smoking on fetal growth and development	
(g) **(i)**	the use of ultrasound for measuring fetal growth	To include the measurement of biparietal diameter of the cranium, crown-rump length of the back. *M0.1, M0.3, M1.3, M1.4, M1.6*
(ii)	the analysis of secondary data from fetal growth charts	

(h)	the advantages and disadvantages of techniques for assessing fetal development and detecting disorders	To include fetal ultrasonography, amniocentesis and chorionic villus sampling.
(i)	the production and use of karyotypes.	To include the use of karyotypes in fetal sex identification and the diagnosis of chromosomal mutations. To include Down's syndrome, Klinefelter's syndrome and Turner's syndrome (no details of non-disjunction are required at AS level).

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3.1.3 The development of species: evolution and classification

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	the concepts of biological classification and species	To include the taxonomic ranks in the hierarchy of classification (domain, kingdom, phylum, class, order, family, genus, species) **AND** an outline of the biological and phylogenetic species concepts.
(b)	the types of evidence used in biological classification and consideration of how theories change as new evidence is found	Evidence for hominid classification to include observable features (e.g. fossils) and molecular evidence (e.g. DNA). HSW7, HSW8
(c)	the use of DNA barcoding in biological classification, examples of the genes used and consideration of the reasons for the choice of these genes	To include the use of mitochondrial genes (e.g. cytochrome c oxidase 1) in animals, and chloroplast genes in plants (no details of electrophoresis are required).
(d)	the interpretation of phylogenetic trees and genetic data to show relatedness and classification in plants and animals	To include consideration of hominids, both extinct and extant, and hylobatids, including examples in which there is conflicting evidence. HSW5, HSW6, HSW8
(e) **(i)**	behavioural, physiological and anatomical adaptations to the environment	To include the following adaptations in *Homo sapiens*: tool use and cultural adaptations for social bonding (behavioural), lactose tolerance and skin pigmentation (physiological), bipedalism and brain size (anatomical) **AND** adaptations of plants to their environment including adaptations to extremes of temperature, light and water.
(ii)	practical investigation into adaptations of plants to environmental factors	

(f)	the evolution of language as an example of a scientific question with many competing theories	To include discussion of why some scientific questions (e.g. "how did language evolve?") are difficult to answer because of a lack of evidence, and consideration of competing theories (to include the "mother tongues" and "gossip" hypotheses). HSW1, HSW2, HSW3, HSW7, HSW8
(g)	adaptation and selection as components of evolution	To include the ideas of genetic variation, selection pressures and natural selection in relation to evolution.
(h)	the definition and measurement of biodiversity	To include calculating Simpson's Index of Diversity (D). The formula will be provided where needed in assessments and does not need to be recalled $D = 1 - \left(\Sigma\left(\frac{n}{N}\right)^2\right)$ To include a consideration that biodiversity can exist at the genetic, species and ecosystem levels. *M0.2, M0.3, M0.4, M1.1, M1.5, M2.3*
(i)	the calculations of genetic diversity within populations.	To include the percentage of gene variants (alleles) in a genome. $\text{proportion of polymorphic gene loci} = \frac{\text{number of polymorphic gene loci}}{\text{total number of loci}}$ *M0.1, M0.2, M1.1, M2.2, M2.4*

3.2 Pathogens, immunity and disease control

In this section, learners study the nature of pathogens and their means of transmission. An understanding of the primary defences and immunological responses of the body to infection, and the management and treatment of communicable diseases will also be considered, including the challenges of controlling the spread of drug-resistant strains. Learners will also gain an appreciation of the need for epidemiological research in this dynamic and changing area of science, and evaluate the associated risks and benefits to the individual and to society.

Learners are expected to apply knowledge, understanding and other skills gained in this section to new situations and/or to solve related problems.

3.2.1 Pathogenic microorganisms

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	how pathogens (including bacteria, viruses and fungi) cause communicable disease	To include an outline of the general mechanisms of pathogenicity by bacteria (toxin production), viruses (taking over cell metabolism) and fungi (enzyme secretion).
(b)	the causes, means of transmission, symptoms and the principal treatment of tuberculosis (TB) and HIV/AIDS	To include droplet infection, details of primary and secondary TB and also opportunistic infections (HIV-AIDS). HSW10

(c)	the structure of the Human Immunodeficiency Virus (HIV)	To include the use of diagrams showing the location of enzymes and the nature of the genetic material.
(d)	**(i)** the use of Gram stain, cell and colony morphology to identify bacteria	
	(ii) the culturing of bacteria and the identification of Gram-positive and Gram-negative bacteria using the Gram staining method on pure cultures	HSW3, HSW4, HSW5, HSW6, HSW8
(e)	how the incidence and prevalence of a communicable disease can change over time	To include the principles of endemic communicable diseases (e.g. chickenpox in the UK), epidemics (e.g. SARS in China, 2002) and pandemics (e.g. H1N1 influenza in 2009).
(f)	calculations of incidence rates, prevalence rates and mortality rates and their importance in epidemiology	*M0.1, M0.3, M0.4*
(g)	the analysis, interpretation and use of epidemiological data	To include the evaluation of graphical data to assess the impact of disease e.g. for HIV and TB infection. *M1.3, M1.7, M3.1, M3.5, M3.6* HSW12
(h)	the importance of reporting notifiable diseases and the role of Public Health England, formerly known as the Health Protection Agency (HPA)	To include examples of notifiable diseases. HSW12
(i)	the social, ethical, economic and biological factors involved in the attempts to control and prevent diseases in the context of HIV/AIDS and TB.	HSW10

3.2.2 The immune system

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	primary defences and non-specific defences against pathogens	Primary defences to include mucus and cilia in the respiratory tract, lysozyme in tears and stomach acid **AND** non-specific immune responses to include phagocytosis and inflammation.
(b)	the mode of action of phagocytes	To include the roles of cytokines, opsonins, phagosomes and lysosomes.
(c)	the different roles and modes of action of B and T lymphocytes in the specific immune response	To include clonal selection and clonal expansion, plasma cells, T helper cells, T killer cells and T regulatory cells.
(d)	the secondary immune response and the role of memory cells in long term immunity	To include T memory cells and B memory cells.
(e)	the structure and general function(s) of antibodies	To include descriptions of antibody structure from diagrams **AND** an outline of the action of opsonins and agglutinins.
(f)	how individuals can be tested for TB and HIV infection	To include antibody tests and antigen tests for both diseases **AND** the Mantoux test for TB.
(g)	the differences between active and passive immunity, and between natural and artificial immunity	To include examples of each type of immunity.
(h)	how allergies can result from hypersensitivity of the immune system.	To include an outline of the sequence of events in a typical allergic response to allergens such as pollen (hay fever).

3.2.3 Controlling communicable diseases

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	the principles of vaccination	To include the different forms of vaccines (live vaccine, dead microorganisms, pathogen fragments) and the importance of booster vaccinations.
(b)	the role of vaccination programmes in the prevention of epidemics	To include reference to the establishment of herd immunity.
(c)	the biological problems in the development of vaccines and the use of vaccination programmes	To include issues with vaccine development, mutation rate and antigen variability (e.g. in HIV and the influenza virus(es)) and live vaccines **AND** vaccine use – storage of vaccine, distribution of vaccine and the nutritional status of the target population e.g. if protein deficient.
(d)	the ethical issues related to the development and use of vaccines	To include the use of a vaccine in girls against Human Papilloma Virus (HPV) to prevent cervical cancer. HSW10
(e)	the use of antibiotics in the treatment of communicable disease	To include an outline of the modes of action of antibiotics e.g. inhibition of bacterial protein, DNA and cell wall synthesis **AND** the cellular differences between prokaryotic and eukaryotic cells that allow antibiotics to act on bacterial but not human cells.
(f)	how the misuse of antibiotics can lead to the evolution of resistant strains of bacteria	To include reference to TB and MRSA.
(g)	practical investigation on the effect of antibiotics on Gram-positive and Gram-negative bacteria.	To include bacteriostatic and bacteriocidal effects of antibiotics and the effects of disinfectant use and other hygiene practices. *M0.1, M0.2, M0.4, M1.1, M4.1* **PAG1, PAG7** HSW3, HSW4, HSW5, HSW6, HSW8

3.3 Non-communicable diseases

In this section, an understanding of non-communicable diseases will be illustrated by reference to cancer, smoking-induced lung diseases and asthma.

Learners will use their knowledge of cell division from Module 3.1 to further their understanding of the cellular and genetic basis of cancer. The computerised technological devices and tests that enable early detection and diagnosis of cancer will also be considered, as well as the use of genetic screening to assess potential risks.

Consideration will be given to the analysis of epidemiological data when evaluating the causes of non-infectious diseases, and learners will consider the importance of clinical trials when developing new medicinal treatments. The role of government health agencies in providing national guidelines for treatments is also explored.

In this section, learners will consider the biological and ethical implications of medical and scientific advancements and evaluate the associated risks and benefits to society.

Learners are expected to apply knowledge, understanding and other skills gained in this section to new situations and/or to solve related problems.

3.3.1 The cellular basis of cancer and treatment

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	the factors that may increase the risk of developing non-communicable diseases	Factors to include heredity, ageing, types of radiation, carcinogen, viruses and air pollution and diseases to include cancers and asthma **AND** to include an evaluation of epidemiological and other evidence to identify correlations.
(b)	the cellular basis of cancer	To include an outline of cell cycle control and the changes in control which lead to the formation of tumours and metastases.
(c)	how mutations to proto-oncogenes can lead to cancer	To include Ras and Myc proto-oncogenes.
(d)	how mutations to tumour suppressor genes can lead to cancer	To include the p53 gene.
(e)	the evaluation of epidemiological evidence linking potential risk factors with particular forms of cancer	To include smoking and lung cancer, diet and bowel cancer, BRCA1 gene mutations and breast cancer. *M1.3, M1.5, M1.7, M3.1* HSW5, HSW6
(f)	the methods used to detect cancers	To include references to MRI, X-rays, mammography, CT scans, ultrasound, PET scans, biopsies and blood tests.

(g)	the ethical and economic considerations when screening and conducting genetic tests for cancer	To include evaluation of screening for particular cancers e.g. the potential harm, accuracy and cost of the screening procedure **AND** discussion of the ethics of genetic tests e.g. for BRCA and HNPCC genes. HSW9, HSW10
(h)	the methods used to treat patients with cancer.	To include surgery, chemotherapy, radiotherapy, immunotherapy (monoclonal antibodies), complementary therapies and hormone-related treatment.

3.3.2 Respiratory diseases and treatment

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	the short-term and long-term effects of pollutants on the respiratory system	To include tobacco smoke, asbestos and fungal spores.
(b)	the causes and symptoms of chronic bronchitis and emphysema (COPD), asthma and lung cancer	
(c)	comparisons of acute and chronic diseases	
(d)	the treatment of asthma	To include the use of beta agonists and steroids.
(e)	the importance of plants as potential sources of medicinal drugs	To include the use of theophylline (from *Theobroma cacao*) in the treatment of COPD and asthma, topotecan (from *Camptotheca acuminata*) in the treatment of lung cancer, aspirin (from *Salix spp.*) and quinine (from *Cinchona spp.*).
(f)	the design and use of clinical trials to assess the value of treatments	To include the role of each phase of a clinical trial and the importance of the recruitment and size of sample, randomisation, placebos and double-blind trials. *M1.5* HSW9, HSW10, HSW11
(g)	the role of NICE (The National Institute for Health and Care Excellence) in providing guidelines for treatments.	To include its role in providing guidelines on clinical practice, health technologies and public health **AND** the importance of economic considerations in the production of guidelines. HSW9, HSW10, HSW11

Module 4: Energy, reproduction and populations

4.1 Energy, metabolism and exercise

This section builds on the knowledge and understanding gained in Module 2 by considering the role of ATP as an immediate source of energy for biological processes and the biochemical pathways of cellular respiration that generate ATP.

The concept of aerobic fitness is explored in the context of the effects of exercise on the respiratory and cardiovascular systems. The effects of exercise on skeletal muscles and the mechanism of muscle contraction at cellular level are also considered.

The process of cellular respiration requires an efficient supply of oxygen and the importance of respiratory pigments as oxygen carriers is illustrated by reference to haemoglobin and myoglobin. Learners also gain an insight into the unique properties of fetal haemoglobin in meeting the metabolic needs of the fetus during development.

Learners are expected to apply knowledge, understanding and other skills gained in this section to new situations and/or to solve related problems.

4.1.1 Cellular respiration

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	an outline of glycolysis as an enzyme controlled metabolic pathway	To include the location of the enzymes (only dehydrogenase to be named), the conversion of glucose to triose phosphate, the production of pyruvate, reduced NAD and the production of ATP by substrate level phosphorylation. HSW8
(b)	an outline of the link reaction	To include the location of the enzymes, decarboxylation and dehydrogenation of pyruvate (3C) to acetyl (2C) coenzyme A, and the reduction of NAD. HSW8
(c)	an outline of the Krebs cycle	To include the location of the enzymes, the formation of citrate from the acetyl group of acetyl CoA and oxaloacetate, the conversion of citrate to oxaloacetate using decarboxylation and dehydrogenation reactions and the production of reduced NAD and reduced FAD and also ATP by substrate level phosphorylation (names of intermediate compounds are not required). HSW8

(d)	an outline of the process of oxidative phosphorylation	To include the location of the process and the roles of electron carriers, oxygen and the mitochondrial cristae (inner membrane) **AND** to include the electron transport chain, proton gradients and ATP synthase. HSW8
(e)	an outline of the process of anaerobic respiration in muscle cells and in yeast	To include an appreciation that anaerobic respiration produces a much lower yield of ATP than aerobic respiration.
(f)	the relative energy values of different respiratory substrates	To include the calculation and interpretation of respiratory quotients for carbohydrates, proteins and lipids. $RQ = \frac{CO_2\ produced}{O_2\ consumed}$ *M0.3, M2.3, M2.4* HSW8, HSW12
(g) **(i)**	the use of respirometers and other methods to investigate the rate of respiration	*M0.1, M0.2, M0.3, M1.1, M1.2, M1.3, M1.6, M1.9, M3.2, M3.3, M3.5, M3.6* **PAG4** HSW2, HSW3, HSW4, HSW5, HSW6
(ii)	practical investigations into the effect of temperature, substrate concentration, anaerobic conditions and different respiratory substrates on the rate of respiration.	

4.1.2 Metabolism and exercise

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	the consequences of exercise on the body	To include both immediate and long term effects on the respiratory and cardiovascular systems and on skeletal muscle. HSW12
(b)	the factors affecting aerobic fitness	To include age, gender and participation in exercise.
(c)	practical investigations into the effect of factors on (resting) heart rate, breathing rate or recovery times and the analysis of primary and secondary data	*M0.1, M0.2, M0.3, M1.1, M1.2, M1.3, M1.6, M1.9, M3.2, M3.5* **PAG10** HSW3, HSW4, HSW5, HSW6, HSW12

(d)	**(i)**	how training can significantly improve aerobic fitness	To include frequency, intensity, type and time (duration) (F.I.T.T. factors) of exercise programme. *M0.1, M0.2, M0.3, M1.1, M1.2, M1.3, M1.6, M1.9, M3.5* **PAG10** HSW4, HSW5, HSW6, HSW12
	(ii)	practical investigations into the effects of F.I.T.T. factors on (resting) heart rate, breathing rate or recovery times	
(e)		supplementary methods of enhancing athletic performance	To include the description and evaluation of carbohydrate loading diets, the use of recombinant erythropoietin (RhEPO), blood doping and use of steroids.
(f)		the significance of VO_2 max as a measure of aerobic fitness	To include considerations of VO_2 max as the maximum rate at which oxygen can be taken in, transported and utilised. *M0.1, M0.2, M1.9, M3.1* HSW1, HSW3, HSW4, HSW5, HSW6, HSW9, HSW10, HSW12
(g)		the role of haemoglobin in oxygen transport	
(h)		the oxygen dissociation curves for different respiratory pigments	To include the differences in affinity for oxygen between adult haemoglobin, fetal haemoglobin and myoglobin and the reasons for the differences. *M0.1, M0.2, M1.1, M1.2, M1.6, M3.1, M3.4, M3.6* HSW8
(i)		the factors which affect oxygen dissociation from respiratory pigments	To include temperature, pH, carbon dioxide and the role of carbonic anhydrase.
(j)		the build-up of an oxygen deficit and oxygen debt/EPOC (Excess Post-exercise Oxygen Consumption)	To include the differences between the oxygen deficit and oxygen debt.
(k)	**(i)**	the histology and ultrastructure of skeletal muscle	To include the interpretation of diagrams, photomicrographs and electron micrographs. *M0.1, M0.2, M1.1, M1.2, M1.8*
	(ii)	observations of muscle tissue made using a light microscope and muscle tissue responses to ATP and other solutions	To include muscle dissections e.g. chicken leg with thigh. *M0.1, M0.2, M1.1, M1.2, M1.8* **PAG1** HSW4, HSW5, HSW6
(l)		the sliding filament theory of muscle contraction.	To include the role of actin, myosin, troponin, tropomyosin, the importance of the power stroke and the role of ATP and calcium ions. HSW8

4.2 Mammalian reproduction

This section builds on the knowledge and understanding of cell division gained in Module 3 by introducing learners to the process of gametogenesis and its role in human reproduction. The hormonal regulation of both gametogenesis and the female reproductive cycle will be considered, as well as the part played by hormones in enabling natural conception to occur.

Learners will also gain an understanding of the treatments and procedures that have been developed by endocrinologists to assist conception, including IVF and ICSI, and the issues that couples need to consider in order to make informed and ethical choices.

This section also considers the biological and ethical issues associated with infertility and the effects of ageing on the reproductive systems of men and women.

Learners are expected to apply knowledge, understanding and other skills gained in this section to new situations and/or to solve related problems.

4.2.1 Fertility and assisted reproduction

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	the parts of the male and female urinogenital systems	To include the interpretation of diagrams, photomicrographs and electron micrographs. *M0.1, M0.2, M1.1, M1.2, M1.8*
(b)	**(i)** the histology of the ovaries and testes	To include the interpretation of diagrams, photomicrographs and electron micrographs. *M0.1, M0.2, M1.1, M1.2, M1.8*
	(ii) observations of the histology of the ovaries and testes made using the light microscope	**PAG1** HSW4, HSW5, HSW6
(c)	the process of gametogenesis	To include oogenesis and spermatogenesis and relate these to mitosis and meiosis.
(d)	the structure of the secondary oocyte and sperm related to their functions	To include the interpretation of diagrams, photomicrographs and electron micrographs. *M0.1, M0.2, M1.1, M1.2, M1.8*
(e)	the role of hormones in gametogenesis	To include spermatogenesis: FSH, GnRH, LH, testosterone and inhibin **AND** oogenesis: FSH, LH, progesterone, oestrogen and GnRH.
(f)	the role of hormones in the regulation of the menstrual cycle	To include LH, FSH, progesterone and oestrogen.

(g)	the process of fertilisation	To include the importance in restoring chromosome number and introducing genetic variation.
(h)	the use of monoclonal antibodies in pregnancy testing	No details of the production of monoclonal antibodies are required.
(i)	a consideration and evaluation of the biological and ethical issues surrounding infertility	To include the production of abnormal sperm, low sperm count and blocked vas deferens, ovulatory disorders, oviduct blockage, endometriosis and anti-sperm antibodies. *M0.1, M0.2, M1.1, M1.2, M1.8*
(j)	assisted reproduction	Treatments and techniques to include intrauterine insemination, IVF, intra-cytoplasmic sperm injection (ICSI), donor sperm insemination, surgical sperm retrieval, ovulation induction, frozen embryo replacements and gamete intra-fallopian transfer. HSW9, HSW10, HSW12

4.2.2 The effects of ageing on the reproductive system

	Learning outcomes	**Additional guidance**
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	the effects of ageing on the female reproductive system	To include the changes in physiology associated with ageing (changes in hormone levels, fertility and the menopause).
(b)	managing the effects of ageing on the female reproductive system	To include the use of HRT with its advantages and disadvantages and the use of alternative treatments. HSW5, HSW6, HSW9, HSW10, HSW11
(c)	the effects of ageing on the male urinogenital system.	To include changes in hormone levels and fertility, changes in erectile function and the consequences of benign prostate hyperplasia. HSW5, HSW6, HSW9, HSW10, HSW11

4.3 Photosynthesis, food production and populations

This section begins with a consideration of the biochemical pathways of photosynthesis and its importance as a synthetic process upon which most food chains and food webs are based.

Learners gain an appreciation of the role of microorganisms in recycling materials within the environment and maintaining balance within ecosystems. Microorganisms are also used as natural biosensors by environmental biologists to detect and measure the presence of chemical compounds in the environment.

In this section learners consider ecosystems on different scales from the small (the rumen of many herbivores) to the very large (farms required for global food production). The need to conserve environmental resources in a sustainable fashion is considered, whilst appreciating the potential conflict arising from the needs of an increasing human population. Learners also consider the impacts of human activities on the natural environment and biodiversity.

Learners are expected to apply knowledge, understanding and other skills gained in this section to new situations and/or to solve related problems.

4.3.1 Photosynthesis, food production and management of the environment

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	**(i)** the ultrastructure of the chloroplast	To include the location of the components for the light-dependent reaction in the thylakoid membranes (light harvesting complexes, photosystems, electron transport chain and ATP synthase) and the location of the enzymes for the light-independent reactions in the stroma.
	(ii) practical investigation into the separation of pigments by paper chromatography	No details of the structure of carotenoids or accessory pigments are required. *M1.1, M1.2, M1.3, M1.6, M1.7, M1.8* **PAG6** HSW4, HSW5, HSW6
(b)	the process of the light-dependent stage of photosynthesis	To include the transfer of light energy to chemical energy in the form of ATP and reduced NADP (details of cyclic and non-cyclic photophosphorylation are not required). HSW8

(c)		the production of complex organic molecules in the light-independent stage of photosynthesis (Calvin cycle)	To include the use of the products of the light-dependent reactions (ATP and reduced NADP) within the light-independent reactions **AND** the role of carbon dioxide, ribulose bisphosphate carboxylase (RuBisCO), ribulose bisphosphate (RuBP), glycerate-3-phosphate (GP) and triose phosphate (TP) but no other biochemical detail is required. *M1.1, M1.2, M1.3, M1.6, M1.7, M3.5* HSW4, HSW5, HSW6, HSW8
(d)	**(i)**	practical investigations into the factors affecting photosynthesis	To include light wavelength, light intensity, light duration, temperature and pH. *M1.1, M1.2, M1.3, M1.6, M1.7, M1.9, M3.5* **PAG4** HSW3, HSW4, HSW5, HSW6
	(ii)	practical investigations of the Hill Reaction (light dependent reaction) using DCPIP	*M1.1, M1.2, M1.3, M1.6, M1.7, M3.5* **PAG4** HSW3, HSW4, HSW5, HSW6
(e)		the metabolism of TP and GP to produce carbohydrates, lipids and amino acids	To include reference to the need for appropriate mineral ions (e.g. nitrates and sulfates in relation to amino acids).
(f)		the dependency of respiration in plants and animals upon the products of photosynthesis	
(g)	**(i)**	the biological significance of the compensation point for crop production	
	(ii)	an interpretation of data and graphs relating to the biological significance of the compensation point for crop production	*M3.4, M3.5*
	(iii)	practical investigation of different leaf samples to compare compensation points with hydrogencarbonate indicator solution	*M1.1, M1.2, M1.3, M1.6, M1.7, M3.4, M3.5* HSW3, HSW4, HSW5, HSW6
(h)	**(i)**	the importance of microorganisms in maintaining ecosystems, with reference to the nitrogen cycle	To include the recycling of nitrogen by bacteria, with reference to the roles of *Azotobacter*, *Nitrosomonas*, *Nitrobacter* and *Rhizobium* **AND** the use of luminescent microorganisms as biosensors in environmental monitoring.
	(ii)	culturing of *Rhizobium spp. in vitro*	*M1.8* **PAG1** HSW4, HSW5, HSW6
	(iii)	investigating the appearance of root nodules in legumes	*M1.8* HSW4, HSW5, HSW6

(i)	the transfer of biomass through a food chain in food production	*M0.4, M1.2, M1.6*
(j)	a consideration of the efficiency of biomass transfers in the food chain with reference to their comparative ability to provide resources in a sustainable fashion	To include fish farming and maize grown as animal feed for beef cattle reared for human consumption. $efficiency = \frac{biomass\ transferred}{biomass\ intake} \times 100$
(k)	the role of ruminants in the human food chain	To include an outline of the structure and composition of the ruminant digestive system as an ecosystem and the role of microorganisms within this ecosystem in the digestion of cellulose, the production of fatty acids and as a source of protein.
(l) **(i)**	farms as ecosystems	To include a consideration of farms as ecosystems where biotic and abiotic factors impact on productivity **AND** the features of intensive and extensive farming to include the advantages and disadvantages with reference to hedgerow removal, use of chemicals, disposal of farm waste and consideration of government schemes such as the countryside stewardship scheme.
(ii)	the potential for conflict between agriculture and conservation	
(m) **(i)**	how land management can result in deflected succession	To include descriptions of succession as a dynamic process moving from colonisation to climax communities **AND** how examples of land management practices (to include forestry and agriculture) can deflect succession. HSW9, HSW10, HSW11
(ii)	practical investigations of differences in biodiversity using techniques such as random and systematic sampling.	*M1.5, M1.6, M1.7, M2.3* **PAG3** HSW4, HSW5, HSW6

4.3.2 The impact of population increase

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	the factors that alter the birth rate and death rate in human populations	To include food production, advances in medical technology and disease control **AND** interpretation of demographic charts/graphs. *M1.3, M1.5, M3.2, M3.5*
(b)	the impact of the rise in human population on ecosystems and biodiversity	To include the impacts of humans on the global ecosystem (e.g. impact on abiotic factors such as climate, soils and water quality and on biotic factors such as changes in biodiversity). *M1.5*
(c)	the ecological, economic and scientific importance of species biodiversity	To include aesthetic, medical and agricultural considerations and the use of statistical methods to assess species biodiversity (e.g. Simpson's Diversity Index). *M1.5, M2.3*
(d)	the global food security agenda concerning sustainable food production and food consumption	To include but not limited to food system challenges (food safety, food fraud, food crime and consumer trust) **AND** the role of the United Nations Food and Agriculture Organisation (to include to FCC (Food Chain Crisis Management Framework) and EMPRES (Emergency Prevention System)).

4.4 From flowers to food

Global food security and sustainability are challenges facing the modern world.

Flowering is a critical stage in the life cycle of a plant and so in the production of staple foods, such as rice and wheat. The timing of flowering must coincide with favourable environmental conditions so that viable seeds can be produced. Learners will consider the different environmental cues which trigger flowering, the adaptations of flowers to different types of pollination and the formation of seeds and their germination.

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4.4.1 Plant reproduction

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	the control of flowering in plants	To include the role of vernalisation and phytochrome in the timing of flowering. HSW2, HSW5, HSW8
(b)	adaptations of flowers for pollination	To include adaptations of both wind-pollinated flowers (e.g. cereals) and insect-pollinated flowers (e.g. legumes). **PAG2** HSW4, HSW5, HSW8
(c)	fertilisation and seed formation	To include the growth of the pollen tube, the formation of the embryo and the formation of the endosperm (in outline only). **PAG2** HSW4, HSW5, HSW8
(d) **(i)**	the germination of seeds	
(ii)	investigations into the factors affecting germination	To include the role of gibberellin as a cell signalling molecule. HSW1, HSW2, HSW8
(e)	the importance of cereals as staple foods	To include a consideration of the global use of rice, maize and wheat, and issues relating to food security and sustainability. HSW9, HSW10, HSW12

Module 5: Genetics, control and homeostasis

5.1 Genetics in the twenty first century

The aim of this section is to develop an understanding of the fundamental principles of heredity, which are illustrated by reference to model organisms and to the inheritance of genetic diseases.

Learners gain an understanding of the regulation of the genome by a number of factors, and the concept of epigenetics will also be considered in relation to the increase in diseases such as Type 2 diabetes.

Some of the practical techniques used to analyse and manipulate DNA are also considered, as well as the applications of these techniques. The potential uses of DNA and RNA technology in the treatment of disease are considered, as is the profound ethical implications of gene technologies and the role of genetic counsellors.

The use of gene technologies to catalogue the accumulation of different genetic information in populations and the implications for speciation can also be considered.

This section provides opportunities for the use of statistical tests in analysing data.

Learners are expected to apply knowledge, understanding and other skills gained in this section to new situations and/or to solve related problems.

5.1.1 Patterns of inheritance

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	patterns of monogenic (monohybrid) inheritance	To include the correct usage of the terms gene, allele (gene variant), locus, phenotype, genotype, dominant and recessive, heterozygous and homozygous and codominant. HSW8
(b)	gene mutations	To include cystic fibrosis, sickle cell anaemia, phenylketonuria (PKU) and Huntington's disease.
(c)	patterns of inheritance which show codominance and multiple gene variants (alleles)	To include the inheritance of blood groups and HLA antigens in humans.
(d)	patterns of inheritance which show sex linkage and autosomal linkage	To include haemophilia (sex linkage) and ABO blood group and nail patella syndrome (autosomal linkage).

(e)	the use of model organisms to investigate patterns of inheritance	To include *Drosophila melanogaster* **AND** patterns of inheritance to include dihybrid inheritance **AND** the use of the chi-squared (X^2) test to analyse various patterns of inheritance. *M1.4, M1.9* HSW1, HSW2, HSW3, HSW5, HSW6
(f)	chromosome mutations in humans	To include non-disjunction and translocations in the context of Turner's syndrome, Klinefelter's syndrome and Down's syndrome.
(g)	the role of the genetic counsellor and the ethical issues involved in advising families where a genetic disease has been identified.	To include pedigree analysis to predict the probability of genetic disease **AND** the use of genetic testing. *M1.4* HSW2, HSW5, HSW8, HSW9, HSW11, HSW12

5.1.2 Population genetics and epigenetics

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	the role of natural selection in changing allele frequencies within populations	To include the link between malaria and the frequency of the sickle cell allele including the effect on the phenotype of each of the three possible genotypes for the normal and sickle cell allele. *M1.4, M1.5, M2.2, M2.3, M2.4*
(b)	the link between the changes in the amino acid sequence to the change in structure and properties of proteins (e.g. haemoglobin)	HSW1, HSW5, HSW6
(c)	the use of Hardy-Weinberg equations to analyse changes in allele frequencies in populations	The equations for the Hardy-Weinberg principle will be provided where needed in assessments and do not need to be recalled $p^2 + 2pq + q^2 = 1$ $p + q = 1$ HSW3, HSW8 *M2.1, M2.2, M2.3, M2.4*
(d)	factors other than natural selection that contribute to genetic biodiversity	To include the role of the founder effect and genetic bottlenecks in creating genetic differences between human populations. Examples to include blood group distribution and Ellis-van Creveld syndrome distribution. HSW1, HSW5, HSW6, HSW9, HSW10, HSW12

(e)	the role of geographical and reproductive isolation in the formation of new species	To include a consideration of the implications for speciation of primates, including humans.
(f)	epigenetics in terms of the effect of environment on gene expression.	To include theories of the role of DNA methylation and histones in gene expression **AND** a review of some human epigenetic studies (such as the Norrbotten studies, studies on the effect of the Dutch Hunger Winter and twin studies) and possible implications from these studies. *M1.7* HSW1, HSW2, HSW5, HSW6, HSW8, HSW9, HSW10, HSW11, HSW12

5.1.3 Gene technologies

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	post transcriptional editing of mRNA	To include the production of mature mRNA in human cells, the nature of introns and exons and the potential to produce many different mature RNA molecules from a single gene (details of splicing mechanisms not required). HSW7, HSW9
(b)	the use of genetic modification of bacterial cells to produce some human proteins	To include the role of reverse transciptase, restriction enzymes, DNA ligase and plasmid vectors **AND** the palindromic nature of recognition sequences for restriction enzymes **AND** the need for reporter genes on plasmids such as those for antibiotic resistance **AND** example of human protein to include insulin. HSW1, HSW3, HSW5, HSW6, HSW7, HSW9, HSW10, HSW11, HSW12
(c)	the principles and uses of the Polymerase Chain Reaction (PCR)	To include the use of PCR in amplifying DNA**,** the role of primers and Taq polymerase in PCR **AND** the use of log scales to show the relationship between cycles of heating and cooling and increases in copy number. *M0.5, M2.5* HSW1, HSW2, HSW3, HSW5, HSW6, HSW7, HSW9, HSW11

(d)	the principles and uses of agarose gel electrophoresis	**PAG6**
(e)	the nature and use of haplotypes, SNPs (single nucleotide polymorphisms) and VNTRs (variable number tandem repeats) in human genome studies	To include forensics, disease pre-disposition, ethnic migration, paternity testing, selection for clinical trials. HSW2, HSW5, HSW6, HSW9, HSW10, HSW11, HSW12
(f)	the use of genetic engineering in eukaryotic cells	To include an outline of the use of genetic engineering to develop knockout mice as models for studying mammalian diseases (no details of genetic crossing to obtain homozygous individuals are required) **AND** an outline of the use of genetic engineering to produce human proteins in animals and genetically modified crops. HSW9, HSW12
(g)	somatic and germ line gene therapy	To include the differences between the two forms of gene therapy **AND** the ethical implications of gene therapy in disease treatment to include the treatment of cystic fibrosis and SCID (severe combined immunodeficiency disease). HSW9, HSW10, HSW11
(h)	the principles of RNA interference.	To include in outline only the action of siRNA and miRNA and the potential of RNA interference in disease treatment. HSW9, HSW10, HSW11, HSW12

5.2 Nervous control

Co-ordination may be chemical or electrical in nature. In this section, learners gain an understanding of the electrical component through the study of the structure and functions of the mammalian nervous system. The use of brain scanning techniques and traditional reflex tests to assess brain injury are investigated. An appreciation of the unique problems associated with damage to neurones is considered, as well as the effects of histological changes in the nervous system as a result of ageing.

The effects of drugs on the nervous system are also considered, including their use in the treatment of neurological conditions such as Parkinson's disease.

The eye is used to illustrate the role of the sensory receptor as a biological transducer. The use of optical scans and eye tests to assess visual function is also explored.

Learners are expected to apply knowledge, understanding and other skills gained in this section to new situations and/or to solve related problems.

5.2.1 The nervous system and the identification and consequences of damage

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	**(i)** the organisation of the somatic and autonomic nervous system in humans	
	(ii) practical observations of nervous tissue using a light microscope	To include the use of diagrams, photomicrographs and electron micrographs to show the structure of the central and peripheral nervous system. *M0.1, M0.2, M1.1, M1.2, M1.8* **PAG1** HSW4, HSW5, HSW6
(b)	the structure and function of the human brain	To include the use of diagrams, photomicrographs and electron micrographs of the locations of the cerebrum, cerebellum, medulla oblongata, hypothalamus and pituitary gland and the functions of each area. *M0.1, M0.2, M1.1, M1.2, M1.8*
(c)	the structure of motor, sensory and relay neurones	To include the use of diagrams, photomicrographs and electron micrographs to show axons, dendrons and dendrites, cell surface membrane and cell body, myelin sheath and nodes of Ranvier. *M0.1, M0.2, M1.1, M1.2, M1.8*

(d)	the establishment of the resting potential and the transmission of the action potential in neurones	To include the interpretation of graphs showing changes in membrane potential, the significance of the myelin sheath and the refractory period in the transmission of nerve impulses. *M3.1, M3.4*
(e)	the structure and function of synapses in integrating responses in the nervous system	To include the role of neurotransmitters in excitatory and inhibitory post synaptic potential.
(f) **(i)**	the nature of a reflex arc, the use of reflexes and the differences when compared to a reaction	Reflexes to include the use of the blink reflex, iris reflex and plantar reflex in assessing nervous system damage and levels of consciousness **AND**
(ii)	practical investigations into reflexes in humans	the use of the Student's *t*-test in investigations of the factors affecting reaction time.
(iii)	practical investigations into factors affecting reaction times	*M0.1, M0.3, M1.1, M1.2, M1.3, M1.6, M3.1, M3.2, M3.4, M3.5* **PAG11** HSW3, HSW4, HSW5, HSW6
(g)	the use of brain scans in assessing brain and spinal cord damage	To include the assessment of traumatic brain injury and strokes and scans to include CT, MRI, fMRI and PET scans and EEGs. HSW9, HSW10, HSW11, HSW12
(h)	the consequences of brain and spinal cord damage	To include effects on memory, motor skills, speech and hormonal imbalance and the ethical consequences of establishing brain death should be discussed. HSW10
(i)	the use of drugs to modify brain activity and function	To include the therapeutic use of drugs, such as dopamine for the treatment of Parkinson's disease and the effect of heroin, cannabis, methamphetamine and alcohol on synapse activity in the brain. HSW5, HSW6, HSW7, HSW9, HSW10, HSW11, HSW12
(j)	psychological and physical drug dependency.	To include the biological basis of dependency and the consequences of dependency on individuals and society. HSW10, HSW12

5.2.2 Monitoring visual function

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	the structure of the eye	To include the location and function of the sclera, conjunctiva, cornea, iris, pupil, lens, ciliary body, aqueous humour, vitreous humour, choroid, and retina.
(b) **(i)**	the structure of the retina	To include the structure and function of the following: rod cells, cone cells, bipolar cells and ganglion cells, the fovea and the blind spot.
(ii)	practical observations of sections through the eye	**PAG1** *M0.1, M0.2, M1.1, M1.2, M1.8*
(c)	the function of the retina as a receptor of light stimuli and as a transducer	
(d)	the assessment of receptor activity through routine eye tests.	To include tests for visual acuity, colour vision and OCT scans (optical coherence tomography). HSW9, HSW10, HSW11, HSW12

5.2.3 The effect of ageing on the nervous system

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	the symptoms and possible causes of Alzheimer's disease	To include histological changes in brain tissue, cognitive impairment and behavioural changes, and genetic and environmental causes. *M1.4, M1.7* HSW5, HSW6, HSW9, HSW10, HSW11
(b) **(i)**	the effect of ageing on the nervous system	To include hearing impairment, visual impairment (cataracts, glaucoma and macular degeneration) and memory loss and the analysis and interpretation of secondary data from hearing tests and sight *tests*.
(ii)	practical investigations into the effect of ageing on reaction times and memory.	*M1.1, M1.3, M1.5, M3.1* **PAG11** HSW4, HSW5, HSW6, HSW9, HSW10, HSW11

5.3 Homeostasis

Homeostasis involves co-ordination which may be chemical or electrical. The aim of this section is to consider the principles of homeostasis with reference to the control of heart rate, body temperature and blood glucose concentration. The implications of a failure of homeostatic mechanisms are also considered.

Learners gain an understanding of the kidney as an organ of homeostasis and excretion, and the effects of kidney disease, and diabetes, are studied.

The ethics of organ donation and the potential uses of cloning and stem cell technology in treatments are also considered.

Learners are expected to apply knowledge, understanding and other skills gained in this section to new situations and/or to solve related problems.

5.3.1 The principles and importance of homeostasis

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	the general principles of homeostasis in the maintenance of a stable internal environment	To include the role of receptors, effectors and negative feedback **AND** the concept of normal ranges for temperature, pH, blood glucose concentration and blood pressure. **AND** contrast positive and negative feedback systems using oxytocin as an example of positive feedback. *M1.6*
(b)	the nervous and hormonal control of heart rate	To include the roles of the sympathetic and parasympathetic nervous system and adrenaline.
(c)	the control of body temperature	To include the role of peripheral temperature receptors, the thermoregulatory centre in the hypothalamus and the responses to rising and falling temperatures (sweating, shivering, vasoconstriction and vasodilation).
(d)	the regulation of thyroxine release and the effect of thyroxine on metabolic rate	
(e)	the techniques for and the importance of measuring core body temperature	To include oral, tympanic (ear), axillary (arm pit) and rectal methods and the significance of readings outside the normal range in adults and children. *M1.1, M1.2, M1.6* **PAG10** HSW3, HSW4, HSW5, HSW6

(f)	the causes, symptoms and treatment of hypothermia and hyperthermia.	To include the consequences of 'fuel poverty' and analysis of data showing correlations between weather conditions and incidence of both hypothermia and hyperthermia with respect to climate change. *M0.3, M1.7* HSW9, HSW10, HSW11, HSW12

5.3.2 The hormonal control of blood glucose and the management of diabetes

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	**(i)** the structure and function of the pancreas as an endocrine gland	To include the use of diagrams, photomicrographs and electron micrographs to identify the Islets of Langerhans and non-endocrine tissues in the pancreas.
	(ii) practical observations of prepared slides of pancreatic tissue using a light microscope	*M0.1, M0.2, M1.8* **PAG1** HSW4
(b)	the regulation of blood glucose by negative feedback	To include details of the action of insulin and glucagon at a cellular level.
(c)	the different types of diabetes	To include the causes, risk factors and diagnosis of Type 1 and Type 2 diabetes.
(d)	the fasting blood glucose test, glucose tolerance testing and the use of biosensors in the monitoring of blood glucose concentrations	To include the analysis and evaluation of secondary data (from glucose tests). *M0.1, M0.2, M1.7* HSW3, HSW4, HSW5, HSW6, HSW9, HSW10, HSW11
(e)	the treatment and management of Type 1 and Type 2 diabetes	To include the use of insulin, lifestyle interventions, the use of drugs and the monitoring of glucose control using glycosylated haemoglobin concentrations. *M0.1, M0.2, M0.3, M1.1, M1.5*
(f)	the team of health professionals involved in the management of diabetes (i.e. the diabetes nurse, dieticians, retinal screeners, podiatrists), including the role of evidence based practice	
(g)	the future impact of diabetes on the human population.	

5.3.3 Kidney functions and malfunctions

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	the need for the removal of excretory products	To include the reasons for the deamination of amino acids and production of urea in liver cells (no details of the ornithine cycle are required).
(b)	the structure of the kidney as part of the excretory system	To include the gross structure of the kidney (cortex, medulla, renal pyramids, renal pelvis and ureter) and relative positions of the major blood vessels and organs associated with the kidney (renal artery and vein, bladder and urethra). **PAG2**
(c) **(i)**	the structure and function of the kidney nephron related to the processes of ultrafiltration and selective re-absorption which result in the production of urine	To include the use of microscopy, diagrams and photomicrographs to examine and identify structures. *M0.1, M0.2, M0.3, M1.8, M2.2* **PAG1** HSW8
(ii)	practical investigations into the biochemical composition of 'mock' urine, renal artery and renal vein plasma and filtrate	**PAG9** HSW3, HSW4, HSW5, HSW6
(d)	the role of the kidney in osmoregulation	To include the location and role of osmoreceptors, the secretion of ADH from the posterior pituitary, the action on ADH at the collecting ducts, the role of cyclic AMP in collecting duct cells and the insertion and removal of aquaporins into cell surface membranes.
(e)	the role of the kidney as an endocrine gland	To include an outline of the homeostatic function of erythropoietin (EPO) and renin (angiotensin).
(f)	the causes, diagnosis and consequence of kidney failure	To include causes (uncontrolled diabetes, kidney stones, blood pressure and bacterial infections), diagnosis (analysis of data from laboratory samples e.g. urine or blood composition) and consequences (renin and EPO changes and cardiovascular disease). *M0.1, M0.3, M2.2, M2.3, M2.4* **PAG9** HSW9, HSW10, HSW11, HSW12

(g)	the use of haemodialysis and peritoneal dialysis in the treatment of kidney failure	To include a consideration of the advantages and disadvantages of both forms. *M1.4* HSW9, HSW10, HSW11, HSW12
(h)	the use of transplant surgery in the treatment of kidney failure	To include practical issues involved in the use of donor organs for kidney transplants. HSW7
(i)	the future for transplant surgery.	To include the implications of therapeutic cloning and reproductive cloning and the use of stem cell technology. HSW7

2d. Prior knowledge, learning and progression

This specification has been developed for learners who wish to continue with a study of biology at Level 3. The A level specification has been written to provide progression from GCSE Science, GCSE Additional Science, GCSE Further Additional Science, GCSE Biology or from AS Level Biology. Learners who have successfully taken other Level 2 qualifications in Science or Applied Science with appropriate biology content may also have acquired sufficient knowledge and understanding to begin the A Level Biology course.

There is no formal requirement for prior knowledge of biology for entry onto this qualification. Other learners without formal qualifications may have acquired sufficient knowledge of biology to enable progression onto the course.

Some learners may wish to follow a biology course for only one year as an AS, in order to broaden their curriculum, and to develop their interest and understanding of different areas of the subject. Others may follow a co-teachable route, completing the one-year AS course and/or then moving to the two-year A level.

The A Level Biology course will prepare learners for progression to undergraduate study, enabling them to enter a range of academic and vocational careers in Biological Sciences, Medicine and Biomedical Sciences, Veterinary Science, Agriculture and related sectors. For learners wishing to follow an apprenticeship route or those seeking direct entry into biological science careers, this A level provides a strong background and progression pathway.

There are a number of Science specifications at OCR. Find out more at www.ocr.org.uk

3 Assessment of OCR A Level in Biology B (Advancing Biology)

3a. Forms of assessment

All three externally assessed components (01–03) contain some synoptic assessment, some extended response questions and some stretch and challenge questions.

Stretch and challenge questions are designed to allow the most able learners the opportunity to demonstrate the full extent of their knowledge and skills.

Stretch and challenge questions will support the awarding of A* grade at A level, addressing the need for greater differentiation between the most able learners.

Fundamentals of biology (Component 01)

This component is worth 110 marks and is split into two sections and assesses content from across all teaching modules. Learners answer all questions.

Section A contains multiple choice questions. This section of the paper is worth 30 marks.

Section B includes short answer question styles (structured questions, problem solving, calculations, practical) and extended response questions. This section of the paper is worth 80 marks.

Scientific literacy in biology (Component 02)

This component assesses content from across all teaching modules and places a particular emphasis on scientific literacy. Learners answer all questions. This component includes a pre-release Advance Notice article (see Section 5e) worth 20 to 25 marks.

Question styles include short answer (structured questions, problem solving, calculations, practical) and extended response questions. This component is worth 100 marks.

Practical skills in biology (Component 03)

This component assesses content from across all teaching modules and places a particular emphasis on practical skills. Learners answer all questions. This component is worth 60 marks.

Question styles include short answer (structured questions, problem solving, calculations, practical) and extended response questions.

Practical Endorsement in biology (Component 04)

Performance in this component is reported separately to the performance in the A level as measured through externally assessed components 01 to 03. This non-exam assessment component rewards the development of practical competency in physics/biology/chemistry and is teacher assessed. Learners demonstrate competence in the range of skills and techniques specified in Section 1.2 of the specification by carrying out a minimum of 12 assessed practical activities. The Practical Endorsement is teacher assessed against the Common Practical Assessment Criteria as specified in Section 5g.

Learners may work in groups but must demonstrate and record independent evidence of their competency. Teachers who award a pass to their learners must be confident that each learner consistently and routinely exhibits the competencies listed in Section 5g and has demonstrated competence in all the apparatus and techniques detailed in Section 1.2.2 before completion of the A level course. The practical activities provided by OCR are all mapped against the specification and assessment criteria.

3b. Assessment objectives (AO)

There are three assessment objectives in OCR's A Level in Biology B (Advancing Biology). These are detailed in the table below.

Learners are expected to demonstrate their ability to:

	Assessment Objective
AO1	Demonstrate knowledge and understanding of scientific ideas, processes, techniques and procedures.
AO2	Apply knowledge and understanding of scientific ideas, processes, techniques and procedures: • in a theoretical context • in a practical context • when handling qualitative data • when handling quantitative data.
AO3	Analyse, interpret and evaluate scientific information, ideas and evidence, including in relation to issues, to: • make judgements and reach conclusions • develop and refine practical design and procedures.

AO weightings in A Level in Biology B (Advancing Biology)

The relationship between the assessment objectives and the components are shown in the following table:

Component	% of A Level in Biology B (H422)		
	AO1	AO2	AO3
Fundamentals of biology (H422/01)	15–17	16–17	7–9
Scientific literacy in biology (H422/02)	10–12	15–17	10–11
Practical skills in biology (H422/03)	5–6	9–10	7–8
Practical endorsement in biology (H422/04)*	N/A	N/A	N/A
Total	**30–35**	**40–44**	**25–28**

* The Practical Endorsement is assessed and reported separately from the overall A level grade (see Section 5)

3c. Assessment availability

There will be one examination series available each year in May/June to **all** learners.

All examined components must be taken in the same examination series at the end of the course.

Assessments by examination must all be taken in a single year

This specification will be certificated from the June 2017 examination series onwards.

3d. Retaking the qualification

Candidates can retake the qualification as many times as they wish. They retake all examined components of the qualification. Candidates can choose either to retake the Practical Endorsement or to carry forward their result for the Practical Endorsement by using the carry forward entry option (see Section 4a). The result for the Practical Endorsement may be carried forward for the lifetime of the specification.

A candidate who is retaking A Level Biology B (Advancing Biology) may re-use a previous result for the Practical Endorsement, even if it was awarded by another awarding organisation or if it was awarded for an alternative suite [e.g. a Practical Endorsement pass result from A Level Biology B (Advancing Biology) could be re-used for retaking A Level Biology A].

3e. Assessment of extended responses

The assessment materials for this qualification provide learners with the opportunity to demonstrate their ability to construct and develop a sustained and coherent line of reasoning and marks for extended responses are integrated into the marking criteria.

3f. Synoptic assessment

Synoptic assessment tests the learners' understanding of the connections between different elements of the subject.

Synoptic assessment involves the explicit drawing together of knowledge, understanding and skills learned in different parts of the A level course. The emphasis of synoptic assessment is to encourage the development of the understanding of the subject as a discipline. All components within Biology B (Advancing Biology) contain an element of synoptic assessment.

Synoptic assessment requires learners to make and use connections within and between different areas of biology, for example, by:

- applying knowledge and understanding of more than one area to a particular situation or context
- using knowledge and understanding of principles and concepts in planning experimental and investigative work and in the analysis and evaluation of data
- bringing together scientific knowledge and understanding from different areas of the subject and applying them.

3g. Calculating qualification results

A learner's overall qualification grade for A Level in Biology B (Advancing Biology) will be calculated by adding together their marks from the three examined components taken to give their total weighted mark.

This mark will then be compared to the qualification level grade boundaries for the entry option taken by the learner and for the relevant exam series to determine the learner's overall qualification grade.

A learner's result for their Practical Endorsement in biology component will not contribute to their overall qualification grade.

4 Admin: what you need to know

The information in this section is designed to give an overview of the processes involved in administering this qualification so that you can speak to your exams officer. All of the following processes require you to submit something to OCR by a specific deadline.

More information about the processes and deadlines involved at each stage of the assessment cycle can be found in the Administration area of the OCR website.

OCR's *Admin overview* is available on the OCR website at http://www.ocr.org.uk/administration.

4a. Pre-assessment

Estimated entries

Estimated entries are your best projection of the number of learners who will be entered for a qualification in a particular series. Estimated entries should be submitted to OCR by the specified deadline. These do not incur a cost and do not commit your centre in any way.

Updated arrangements for monitoring the Practical Endorsement from September 2017

The organisation of the monitoring visits for the Practical Endorsement changes in September 2017. The awarding organisations (AOs) will use information from centre entries for the reformed A levels in biology, chemistry and physics in the previous summer examination series to jointly plan monitoring visits for the September 2017 to May 2019 and subsequent cycles.

Centres will be monitored for a different science than that which was monitored in the previous monitoring cycle. The first contact with a centre will be from the AO with which the science to be monitored was entered in summer 2017. Centres do not need to register details with JCQ or the AO prior to contact regarding the monitoring visit. This first contact will be with the exams officer (or other nominated school contact).

Monitoring visits will follow the same procedures as for 2015 to 2017 and large centres will continue to be monitored for biology, chemistry and physics.

Full details of monitoring and the update are available at http://ocr.org.uk/Images/404146-cross-board-messaging-july-2017-updates-to-the-practical-endorsement-monitoring-process-from-september-2017.pdf which can be found on www.ocr.org.uk/positiveaboutpractical.

Lead teachers are required to have undertaken the free on-line training provided (available and accessible to all teachers at: https://practicalendorsement.ocr.org.uk) on the implementation of the Practical Endorsement. They should also ensure that all other teachers of that science within the centre are familiar with the requirements so that standards are applied consistently.

Final entries

Final entries provide OCR with detailed data for each learner, showing each assessment to be taken. It is essential that you use the correct entry code, considering the relevant entry rules.

Final entries must be submitted to OCR by the published deadlines or late entry fees will apply.

All learners taking A Level in Biology B (Advancing Biology) must be entered for one of the entry options shown on the following table:

Entry option		Components		
Entry code	**Title**	**Code**	**Title**	**Assessment type**
H422A	Biology B (Advancing Biology)	01	Fundamentals of biology	External assessment
		02	Scientific literacy in biology	External assessment
		03	Practical skills in biology	External assessment
		04	Practical Endorsement in biology	Non-exam assessment (Visiting monitoring)
H422C	Biology B (Advancing Biology)	01	Fundamentals of biology	External assessment
		02	Scientific literacy in biology	External assessment
		03	Practical skills in biology	External assessment
		80	Practical Endorsement in biology – Carried Forward*	Non-exam assessment (Carried Forward)

*The carry forward option will be available for the first time from June 2018.

4

Private candidates

Private candidates may enter for OCR assessments.

A private candidate is someone who pursues a course of study independently but takes an examination or assessment at an approved examination centre. A private candidate may be a part-time student, someone taking a distance learning course, or someone being tutored privately. They must be based in the UK.

The A Level Biology B (Advancing Biology) qualification requires candidates to complete a Practical Endorsement incorporating a minimum of 12 practical activities, allowing them to demonstrate a range of practical skills, use of apparatus and techniques to fulfil the Common Practical Assessment Criteria.

The Practical Endorsement is an essential part of the course and will allow candidates to develop skills for further study or employment as well as imparting important knowledge that is part of the specification.

Private candidates need to contact OCR approved centres to establish whether they are prepared to host them as a private candidate. The centre may charge for this facility and OCR recommends that the arrangement is made early in the course.

Further guidance for private candidates may be found on the OCR website: http://www.ocr.org.uk.

Head of Centre Annual Declaration

The Head of Centre is required to provide a declaration to the JCQ as part of the annual NCN update, conducted in the autumn term, to confirm that all candidates at the centre have had the opportunity to undertake the prescribed practical activities.

Please see the JCQ publication *Instructions for conducting non-examination assessments* for further information.

Any failure by a centre to provide the Head of Centre Annual Declaration will result in your centre status being suspended and could lead to the withdrawal of our approval for you to operate as a centre.

4b. Accessibility and special consideration

Reasonable adjustments and access arrangements allow learners with special educational needs, disabilities or temporary injuries to access the assessment and show what they know and can do, without changing the demands of the assessment.

Applications for these should be made before the examination series. Detailed information about eligibility for access arrangements can be found in the JCQ *Access Arrangements and Reasonable Adjustments*.

Special consideration is a post-assessment adjustment to marks or grades to reflect temporary injury, illness or other indisposition at the time the assessment was taken.

Detailed information about eligibility for special consideration can be found in the JCQ *A guide to the special consideration process* and JCQ *Reasonable Adjustments for GCE A-level sciences – Endorsement of practical skills*.

4c. External assessment arrangements

Regulations governing examination arrangements are contained in the JCQ *Instructions for conducting examinations*.

Learners are permitted to use a scientific or graphical calculator for components 01, 02 and 03. Calculators are subject to the rules in the document *Instructions for Conducting Examinations* published annually by JCQ (www.jcq.org.uk).

4d. Admin of non-exam assessment

Regulations governing arrangements for internal assessments are contained in the JCQ *Instructions for conducting non-examination assessments*. Appendix 1 of this document gives specific details for the Practical Skills Endorsement for A Level sciences designed for use in England.

OCR's *Admin overview* is available on the OCR website at http://www.ocr.org.uk/administration.

4e. Results and certificates

Grade scale

A level qualifications are graded on the scale: A*, A, B, C, D, E, where A* is the highest. Learners who fail to reach the minimum standard for E will be Unclassified (U). Only subjects in which grades A* to E are attained will be recorded on certificates.

Results for the A Level Sciences Practical Endorsements will be shown independently of the qualification grade on the certificate. Candidates who fulfil the requirements and reach the minimum standard will be awarded a Pass grade. Candidates who fail to reach the minimum standard will be recorded as 'Not Classified' and this will also be reported on the certificate.

Results

Results are released to centres and learners for information and to allow any queries to be resolved **before** certificates are issued.

Centres will have access to the following results information for each learner:

- the grade for the qualification
- the raw mark for each component
- the total weighted mark for the qualification.

The following supporting information will be available:

- raw mark grade boundaries for each component
- weighted mark grade boundaries for each entry option.

Until certificates are issued, results are deemed to be provisional and may be subject to amendment. A learner's final results will be recorded on an OCR certificate.

The qualification title will be shown on the certificate as 'OCR Level 3 Advanced GCE in Biology B (Advancing Biology)'.

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4f. Post-results services

A number of post-results services are available:

- **Enquiries about results** – If you are not happy with the outcome of a learner's results, centres may submit an enquiry about results.
- **Missing and incomplete results** – This service should be used if an individual subject result for a learner is missing, or the learner has been omitted entirely from the results supplied.
- **Access to scripts** – Centres can request access to marked scripts.
- **Practical Endorsement** – Since monitoring and any potential request for further visits take place throughout the period of the qualification, there is no post-results service provided.

4g. Malpractice

Any breach of the regulations for the conduct of examinations and coursework may constitute malpractice (which includes maladministration) and must be reported to OCR as soon as it is detected.

Detailed information on malpractice can be found in the *Suspected Malpractice in Examinations and Assessments: Policies and Procedures* published by JCQ.

5 Appendices

5a. Overlap with other qualifications

There is a small degree of overlap between the content of this specification and those for other AS level/A level Sciences.

An example of overlap includes:

Chemistry A

- Chromatography.

Chemistry B (Salters)

- Polymers and Life: Amino acids, protein structure, DNA, RNA, chromatography, hydrogen bonding.
- Developing a Medicine: Colorimetry.

5b. Avoidance of bias

The A level qualification and subject criteria have been reviewed in order to identify any feature which could disadvantage candidates who share a protected Characteristic as defined by the Equality Act 2010. All reasonable steps have been taken to minimise any such disadvantage.

5c. How Science Works (HSW)

How Science Works (HSW) was conceived as being a wider view of science in context, rather than just straightforward scientific enquiry. It was intended to develop learners as critical and creative thinkers, able to solve problems in a variety of contexts.

Developing ideas and theories to explain the operation of living systems, from the molecular to the ecosystem level, is at the heart of biology. Learners should be aware of the importance that peer review and repeatability have in giving confidence to this evidence.

Learners are expected to understand the variety of sources of data available for critical analysis to provide evidence and the uncertainty involved in its measurement. They should also be able to link that evidence to contexts influenced by culture, politics and ethics.

Understanding *How Science Works* requires an understanding of how scientific evidence can influence ideas and decisions for individuals and society, which is linked to the necessary skills of communication for audience and for purpose with appropriate scientific terminology.

The examples and guidance within the specification are not exhaustive but give a flavour of opportunities for integrating HSW within the course. These references, written in the form HSW1, link to the statements as detailed below:

- **HSW1** Use theories, models and ideas to develop scientific explanations
- **HSW2** Use knowledge and understanding to pose scientific questions, define scientific problems, present scientific arguments and scientific ideas
- **HSW3** Use appropriate methodology, including information and communication technology (ICT), to answer scientific questions and solve scientific problems
- **HSW4** Carry out experimental and investigative activities, including appropriate risk management, in a range of contexts
- **HSW5** Analyse and interpret data to provide evidence, recognising correlations and causal relationships
- **HSW6** Evaluate methodology, evidence and data, and resolve conflicting evidence
- **HSW7** Know that scientific knowledge and understanding develops over time
- **HSW8** Communicate information and ideas in appropriate ways using appropriate terminology
- **HSW9** Consider applications and implications of science and evaluate their associated benefits and risks
- **HSW10** Consider ethical issues in the treatment of humans, other organisms and the environment
- **HSW11** Evaluate the role of the scientific community in validating new knowledge and ensuring integrity
- **HSW12** Evaluate the ways in which society uses science to inform decision making.

5d. Mathematical requirements

In order to develop their skills, knowledge and understanding in A Level Biology, learners need to have been taught, and to have acquired competence in, the appropriate areas of mathematics relevant to the subject as indicated in the M0 – M4 table of coverage below.

The assessment of quantitative skills will include at least 10% Level 2 (or above) mathematical skills for biology (see later for a definition of 'Level 2' mathematics).

These skills will be applied in the context of the relevant biology.

All mathematical content will be assessed within the lifetime of the specification. Skills shown in **bold** type in the M0 – M4 coverage table below will only be tested in the full A Level course, not the standalone AS Level course.

The list of examples given in the M0 – M4 coverage table is not exhaustive and is not limited to Level 2 examples. These skills could be developed in other areas of the specification content from those indicated.

Formulae used in A Level Biology

To address biology questions using mathematical skills, learners will need to be able to use and, in some cases, recall formulae and equations. Some of these will seem like pure mathematics, but will be deployed in biological contexts, while others are clearly biological equations, albeit manipulated using standard mathematical, algebraic techniques.

	Biological	**Mathematical**
Recall	Magnification Rates R_f SA : V Genetic biodiversity Cardiac output RQ Efficiency	All of GCSE (9–1) Maths recall including (but not limited to): • circumference and area of circle • surface area and volume of cuboid • mean • percentage (to include %change, %yield and %error)
Provided	Hardy-Weinberg Simpson's index of diversity	Surface area and volume of cylinder and sphere chi squared *t*-test paired *t*-test unpaired Spearman's rank Standard deviation

GCSE (9–1) Mathematical formulae to recall

At AS and A Level Biology we assume knowledge of higher tier GCSE (9–1) Maths content. This includes (but is not limited to) the following list of formulae which learners will need to be able to recall.

Note that students should be familiar with the convention of using *r* for radius, *h* for height, *b* for base and *l* for length.

- Circumference of circle

  $$Circumference = 2\pi r$$

- Area of circle

  $$Area\ of\ circle = \pi r^2$$

- Surface area of cuboid

  $$Surface\ area\ of\ cuboid = 2(bh + bl + hl)$$

- Volume of cuboid

  $$Volume\ of\ Cuboid = hbl$$

- Mean

  $$\bar{x} = \frac{\Sigma x}{n}$$

- Percentage (which can be used to calculate percentage change, percentage yield and percentage error)

  $$Percentage\ change = \frac{new\ quantity - original\ quantity}{original\ quantity} \times 100$$

  $$\%\ yield = \frac{Actual\ Amount}{Theoretical\ Amount} \times 100$$

  $$\%\ error\ (uncertainty) = \frac{2 \times absolute\ uncertainty}{quantity\ measured} \times 100\%$$

Biological formulae to recall

The following are the biological formulae learners will need to recall:

- Magnification

  $$Magnification = \frac{size\ of\ image}{size\ or\ real\ object}$$

- R_f

  $$Rf = \frac{distance\ moved\ by\ the\ solute}{distance\ moved\ by\ the\ solvent}$$

- Rates (e.g. enzymatic reactions, breathing (ventilation), transpiration, photosynthesis, respiration, reaction times, diffusion)

  $$Rate = \frac{change\ in\ quantity}{time\ taken}$$

- Surface Area to Volume ratio

$$Ratio = \frac{Surface\ Area}{Volume}$$

- Genetic biodiversity

$$proportion\ of\ \ polymorphic\ gene\ loci = \frac{number\ of\ \ polymorphic\ gene\ loci}{total\ number\ of\ \ loci}$$

- Cardiac output as a function of heart rate and stroke volume

$$cardiac\ output = heart\ rate \times stroke\ volume$$

- Respiratory quotient

$$RQ = \frac{CO_2\ produced}{O_2\ consumed}$$

- Efficiency of biomass transfers

$$efficiency = \frac{biomass\ transferred}{biomass\ intake} \times 100$$

Mathematical formulae that will need to be used but not recalled (provided in the assessments where needed).

- Surface area of a cylinder

$$Surface\ area\ of\ \ cylinder = 2\pi r(r + l)$$

- Volume of a cylinder

$$Volume\ of\ \ cylinder = \pi r^2 l$$

- Surface area of a sphere

$$Surface\ area\ of\ \ sphere = 4\pi r^2$$

- Volume of a sphere

$$Volume\ of\ \ sphere = \frac{4}{3}\pi r^3$$

- Chi squared

$$\chi^2 = \Sigma \frac{(f_o - f_e)^2}{f_e}$$

- Spearman's Rank Correlation Coefficient

$$r_s = 1 - \frac{6\Sigma d^2}{n(n^2 - 1)}$$

- Standard Deviation

$$s = \sqrt{\frac{\Sigma (x - \bar{x})^2}{n - 1}}$$

- Student's *t*-test – Unpaired

$$t = \frac{|\bar{x}_A - \bar{x}_B|}{\sqrt{\frac{s^2_A}{n_A} + \frac{s^2_B}{n_B}}}$$

- Student's *t*-test – Paired

$$t = \frac{\bar{d}\sqrt{n}}{s_d}$$

Note that critical values tables, or appropriate excerpts from these tables, will be provided in the assessment where needed.

Learners will need to be able to work out which 'degrees of freedom' or 'n' row, and which confidence column(s) is/are relevant to their analysis.

Biological formulae that will need to be used but not recalled (provided in the assessments where needed):

- The Hardy-Weinberg Equations

$$p^2 + 2pq + q^2 = 1$$

$$p + q = 1$$

- Simpson's Index

$$D = 1 - \left(\Sigma\left(\frac{n}{N}\right)^2\right)$$

Mathematics skills for biology – M0 – M4 coverage table

	Mathematical skill to be assessed	Exemplification of the mathematical skill in the context of A Level Biology (assessment is not limited to the examples below)	Areas of the specification which exemplify the mathematical skill (assessment is not limited to the examples below)
M0 – Arithmetic and numerical computation			
M0.1	Recognise and make use of appropriate units in calculations	Learners may be tested on their ability to: • convert between units e.g. mm^3 to cm^3 as part of volumetric calculations • work out the unit for a rate e.g. breathing rate.	1.1.1(b), 1.1.2(b), 2.1.1(e), 2.1.1(i), 2.1.1(m), 2.1.2(b), 2.1.2(c), 2.1.3(d), 2.2.1(e), 2.2.1(f), 2.2.1(g), 2.2.3(c), 2.2.4(b), 2.2.4(e), 3.1.2(g), 3.1.3(i), 3.2.1(f), 3.2.3(g), 4.1.1(g), 4.1.2(c), 4.1.2(d), 4.1.2(f), 4.1.2(h), 4.1.2(k), 4.2.1(a), 4.2.1(b), 4.2.1(d), 4.2.1(i), 5.2.1(a), 5.2.1(b), 5.2.1(c), 5.2.1(f), 5.2.2(b), 5.3.2(a), 5.3.2(d), 5.3.2(e), 5.3.3(c), 5.3.3(f)
M0.2	Recognise and use expressions in decimal and standard form	Learners may be tested on their ability to: • use an appropriate number of decimal places in calculations, e.g. for a mean • carry out calculations using numbers in standard and ordinary form, e.g. use of magnification • understand standard form when applied to areas such as size of organelles • convert between numbers in standard and ordinary form	2.1.1(e), 2.1.1(i), 2.1.1(m), 2.1.2(b), 2.1.2(c), 2.2.4(b), 2.2.4(e), 3.1.3(h), 3.1.3(i), 3.2.3(g), 4.1.1(g), 4.1.2(c), 4.1.2(d), 4.1.2(f), 4.1.2(h), 4.1.2(k), 4.2.1(a), 4.2.1(b), 4.2.1(d), 4.2.1(i), 4.2.2(a), 5.2.1(a), 5.2.1(b), 5.2.1(c), 5.2.2(b), 5.3.2(a), 5.3.2(d), 5.3.2(e), 5.3.3(c)
		• understand that significant figures need retaining when making conversions between standard and ordinary form, e.g. 0.0050 mol dm^{-3} is equivalent to 5.0×10^{-3} mol dm^{-3}.	

	Mathematical skill to be assessed	Exemplification of the mathematical skill in the context of A Level Biology (assessment is not limited to the examples below)	Areas of the specification which exemplify the mathematical skill (assessment is not limited to the examples below)
M0.3	Use ratios, fractions and percentages	Learners may be tested on their ability to: • calculate percentage yields • calculate surface area to volume ratio • use scales for measuring • represent phenotypic ratios (monohybrid and dihybrid crosses).	2.1.1(e), 2.1.2(b), 2.1.2(c), 2.1.2(g), 2.1.2(h), 2.1.4(c), 2.2.1(a), 3.1.2(g), 3.1.3(h), 3.2.1(f). 4.1.1(f), 4.1.1(g), 4.1.2(c), 4.1.2(d), 5.2.1(f), 5.3.1(f), 5.3.2(e), 5.3.3(c), 5.3.3(f)
M0.4	Estimate results	Learners may be tested on their ability to: • estimate results to sense check that the calculated values are appropriate.	2.2.1(e), 2.2.1(f), 2.2.1(g), 3.1.3(h), 3.2.1(f), 3.2.1(g), 4.3.1(i)
M0.5	**Use calculators to find and use power, exponential and logarithmic functions**	**Learners may be tested on their ability to:** • **estimate the number of bacteria grown over a certain length of time.**	**5.1.3(c)**
M1 – Handling data			
M1.1	Use an appropriate number of significant figures	Learners may be tested on their ability to: • report calculations to an appropriate number of significant figures given raw data quoted to varying numbers of significant figures • understand that calculated results can only be reported to the limits of the least accurate measurement.	1.1.3(c), 2.1.1(i), 2.1.1(m), 2.1.2(b), 2.1.2(c), 2.1.2(g), 2.1.2(h), 2.2.4(c), 2.2.4(e), 3.1.3(h), 3.1.3(i), 3.2.3(g), 4.1.1(g), 4.1.2(c), 4.1.2(d), 4.1.2(h), 4.1.2(k), 4.2.1(a), 4.2.1(b), 4.2.1(d), 4.2.1(i), 4.2.2(a), 4.3.1(a), 4.3.1(c), 4.3.1(d), 4.3.1(g), 5.2.1(a), 5.2.1(b), 5.2.1(c), 5.2.1(f), 5.2.2(b), 5.2.3(b), 5.3.1(e), 5.3.2(e)

	Mathematical skill to be assessed	Exemplification of the mathematical skill in the context of A Level Biology (assessment is not limited to the examples below)	Areas of the specification which exemplify the mathematical skill (assessment is not limited to the examples below)
M1.2	Find arithmetic means	Learners may be tested on their ability to: • find the mean of a range of data, e.g. the mean number of stomata in the leaves of a plant.	2.1.1(i), 2.1.1(m), 2.1.2(b), 2.1.2(c), 2.1.2(g), 2.1.2(h), 2.1.3(d), 2.2.1(e), 2.2.1(f), 2.2.1(g), 2.2.4(c), 2.2.4(e), 4.1.1(g), 4.1.2(c), 4.1.2(d), 4.1.2(h), 4.1.2(k), 4.2.1(a), 4.2.1(b), 4.2.1(d), 4.2.1(i), 4.2.2(a), 4.3.1(a), 4.3.1(c), 4.3.1(d), 4.3.1(g), 4.3.1(i), 5.2.1(a), 5.2.1(b), 5.2.1(c), 5.2.1(f), 5.2.2(b), 5.3.1(e)
M1.3	Construct and interpret frequency tables and diagrams, bar charts and histograms	Learners may be tested on their ability to: • represent a range of data in a table with clear headings, units and consistent decimal places • interpret data from a variety of tables, e.g. data relating to organ function • plot a range of data in an appropriate format, e.g. enzyme activity over time represented on a graph • interpret data for a variety of graphs, e.g. explain electrocardiogram traces.	2.1.2(c), 2.1.2(g), 2.1.2(h), 2.1.3(d), 2.2.1(e), 2.2.1(f), 2.2.1(g), 2.2.4(e), 3.1.2(g), 3.2.1(g), 3.3.1(f), 4.1.1(g), 4.1.2(c), 4.1.2(d), 4.3.1(a), 4.3.1(c), 4.3.1(d), 4.3.1(g), 4.3.2(a), 5.2.1(f), 5.2.3(b)
M1.4	Understand simple probability	Learners may be tested on their ability to: • use the terms probability and chance appropriately • understand the probability associated with genetic inheritance.	3.1.2(g), 5.1.1(e), 5.1.1(g), 5.1.2(a), 5.2.3(a), 5.3.3(g)
M1.5	Understand the principles of sampling as applied to scientific data	Learners may be tested on their ability to: • analyse random data collected by an appropriate means, e.g. use Simpson's index of diversity to calculate the biodiversity of a habitat.	2.1.1(e), 3.1.3(h),3.3.1(f), 3.3.2(f), 4.3.1(m), 4.3.2(a), 4.3.2(b), 4.3.2(c), 5.1.2(a), 5.2.3(b), 5.3.2(e)

	Mathematical skill to be assessed	Exemplification of the mathematical skill in the context of A Level Biology (assessment is not limited to the examples below)	Areas of the specification which exemplify the mathematical skill (assessment is not limited to the examples below)
M1.6	Understand the terms mean, median and mode	Learners may be tested on their ability to: • calculate or compare the mean, median and mode of a set of data, e.g. height/mass/ size of a group of organisms.	2.1.2(b), 2.1.2(c), 2.2.4(e), 3.1.2(g), 4.1.1(g), 4.1.2(c), 4.1.2(d), 4.1.2(h), 4.3.1(a), 4.3.1(c), 4.3.1(d, 4.3.1(g), 4.3.1(i), 4.3.1(m), 5.2.1(f), 5.3.1(a), 5.3.1(e)
M1.7	Use a scatter diagram to identify a correlation between two variables	Learners may be tested on their ability to: • interpret a scattergram, e.g. the effect of life style factors on health.	3.2.1(g), 3.3.1(f), 4.3.1(a), 4.3.1(c), 4.3.1(d), 4.3.1(g), 4.3.1(m), 5.1.2(f), 5.2.3(a), 5.3.1(f), 5.3.2(d)
M1.8	Make order of magnitude calculations	Learners may be tested on their ability to: • use and manipulate the magnification formula: • magnification = $\frac{\text{size of image}}{\text{size of real object}}$	2.1.1(d), 2.1.1(g), 2.1.1(i), 2.2.4(c), 4.1.2(k), 4.2.1(a), 4.2.1(b), 4.2.1(d), 4.2.1(i), 4.2.2(a), 4.3.1(a), 4.3.1(h), 5.2.1(a), 5.2.1(b), 5.2.1(c), 5.2.2(b), 5.3.2(a), 5.3.3(c)
M1.9	Select and use a statistical test	Learners may be tested on their ability to select and use: • the chi squared (X^2) test to test the significance of the difference between observed and expected results • the Student's *t*-test • the Spearman's rank correlation coefficient.	4.1.1(g), 4.1.2(c), 4.1.2(d), 4.1.2(f), 4.3.1(d), 5.1.1(e)
M1.10	Understand measures of dispersion, including standard deviation and range	Learners may be tested on their ability to: • calculate the standard deviation • understand why standard deviation might be a more useful measure of dispersion for a given set of data e.g. where there is an outlying result.	2.1.1(e), 2.2.1(g)

	Mathematical skill to be assessed	Exemplification of the mathematical skill in the context of A Level Biology (assessment is not limited to the examples below)	Areas of the specification which exemplify the mathematical skill (assessment is not limited to the examples below)
M1.11	Identify uncertainties in measurements and use simple techniques to determine uncertainty when data are combined	Learners may be tested on their ability to: • calculate percentage error where there are uncertainties in measurement.	1.1.4(d), 2.1.3(d), 2.2.1(e), 2.2.1(f), 2.2.1(g), 2.2.4(e)
M2 – Algebra			
M2.1	Understand and use the symbols: =, <, <<, >>, >, α, $\sim$	No exemplification required.	2.2.4(c), 5.1.2(c)
M2.2	Change the subject of an equation	Learners may be tested on their ability to: • use and manipulate equations, e.g. magnification.	2.1.1(i), 2.2.3(c), 3.1.3(i), 5.1.2(a), 5.1.2(c), 5.3.3(c), 5.3.3(f)
M2.3	Substitute numerical values into algebraic equations using appropriate units for physical quantities	Learners may be tested on their ability to: • use a given equation e.g. Simpson's-index of diversity $D = 1 - \sum(n/N)^2$.	2.2.1(e), 2.2.1(f), 2.2.3(c), 3.1.3(h), 4.1.1(f), 4.3.1(m), 4.3.2(c), 5.1.2(a), 5.1.2(c), 5.3.3(f)
M2.4	Solve algebraic equations	Learners may be tested on their ability to: • solve equations in a biological context, e.g. $\text{cardiac output} = \text{stroke volume} \times \text{heart rate}$	2.2.1(e), 2.2.1(f), 2.2.3(c), 3.1.3(i), 4.1.1(f), 5.1.2(a), 5.1.2(c), 5.3.3(f)
M2.5	**Use logarithms in relation to quantities that range over several orders of magnitude**	**Learners may be tested on their ability to:** • **use a logarithmic scale in the context of microbiology, e.g. growth rate of a microorganism such as yeast.**	**5.1.3(c)**
M3 – Graphs			
M3.1	Translate information between graphical, numerical and algebraic forms	Learners may be tested on their ability to: • understand that data may be presented in a number of formats and be able to use these data, e.g. dissociation curves.	1.2.1(g), 2.1.1(m), 2.1.2(b), 2.1.2(c), 2.1.2(g), 2.1.2(h), 2.1.3(d), 2.2.1(e), 2.2.1(f), 2.2.1(g), 2.2.1(h), 2.2.4(e), 3.2.1(g), 3.3.1(f), 4.1.2(f) (h), 5.2.1(d), 5.2.1(f), 5.2.3(b)

	Mathematical skill to be assessed	Exemplification of the mathematical skill in the context of A Level Biology (assessment is not limited to the examples below)	Areas of the specification which exemplify the mathematical skill (assessment is not limited to the examples below)
M3.2	Plot two variables from experimental or other data	Learners may be tested on their ability to: • select an appropriate format for presenting data, bar charts, histograms, graphs and scattergrams.	1.1.3(d), 2.1.1(m), 2.1.2(c), 2.1.2(g), 2.1.2(h), 2.1.3(d), 2.2.1(e), 2.2.1(f), 2.2.1(g), 2.2.4(e), 4.1.1(g), 4.1.2(c), 4.3.2(a), 5.2.1(f)
M3.3	Understand that $y = mx + c$ represents a linear relationship	Learners may be tested on their ability to: • predict/sketch the shape of a graph with a linear relationship, e.g. the effect of substrate concentration on the rate of an enzyme-controlled reaction with excess enzyme.	1.1.3(d), 2.1.1(m), 2.1.3(d), 2.2.4(e), 4.1.1(g)
M3.4	**Determine the intercept of a graph**	**Learners may be tested on their ability to:** • **read off an intercept point from a graph, e.g. compensation point in plants.**	**1.1.3(d), 2.1.2(g), 2.1.2(h), 4.1.2(h), 4.3.1(g), 5.2.1(d), 5.2.1(f)**
M3.5	Calculate rate of change from a graph showing a linear relationship	Learners may be tested on their ability to: • calculate a rate from a graph, e.g. rate of transpiration.	1.1.3(d), 2.1.1(m), 2.1.3(d), 2.2.4(e), 3.2.1(g), 4.1.1(g), 4.1.2(c) (d) (h), 4.3.1(c), 4.3.1(d), 4.3.1(g), 4.3.2(a), 5.2.1(f)
M3.6	Draw and use the slope of a tangent to a curve as a measure of rate of change	Learners may be tested on their ability to: • use this method to measure the gradient of a point on a curve, e.g. amount of product formed plotted against time when the concentration of enzyme is fixed.	1.1.3(d), 2.1.1(m), 2.1.3(d), 2.2.4(e), 3.2.1(g), 4.1.1(g), 4.1.2(h)

	Mathematical skill to be assessed	Exemplification of the mathematical skill in the context of A Level Biology (assessment is not limited to the examples below)	Areas of the specification which exemplify the mathematical skill (assessment is not limited to the examples below)
M4 – Geometry and trigonometry			
M4.1	Calculate the circumferences, surface areas and volumes of regular shapes	Learners may be tested on their ability to: • calculate the circumference and area of a circle • calculate the surface area and volume of rectangular prisms, of cylindrical prisms and of spheres • e.g. calculate the surface area or volume of a cell.	2.1.1(e), 2.1.1(i), 2.2.1(a), 2.2.4(e), 3.2.3(g)

Definition of Level 2 mathematics

Within A Level Biology, 10% of the marks available within written examinations will be for assessment of mathematics (in the context of biology) at a Level 2 standard, or higher. Lower level mathematical skills will still be assessed within examination papers but will not count within the 10% weighting for biology.

The following will be counted as Level 2 (or higher) mathematics:

- application and understanding requiring choice of data or equation to be used
- problem solving involving use of mathematics from different areas of maths and decisions about direction to proceed
- questions involving use of A level mathematical content (as of 2012), e.g. use of logarithmic equations.

The following will not be counted as Level 2 mathematics:

- simple substitution with little choice of equation or data
- structured question formats using GCSE mathematics (based on 2012 GCSE mathematics content).

Additional guidance on the assessment of mathematics within biology is available on the OCR website as a separate resource, the Maths Skills Handbook.

5

5e. Advance Notice for component 02

The A Level in Biology B (Advancing Biology) specification places a particular emphasis on the development of scientific literacy skills, which are assessed at the end of the course using a pre-release Advance Notice article (also included as part of the examination paper for component H422/02). The Advance Notice will be a scientific article/s related to the content within the specification and questions related to the Advance Notice will be worth 20–25 marks.

The Advance Notice will be available for download *via* the OCR website on 13 March each year (starting from 13 March 2017 for the first A level assessment in June 2017) to enable teachers and learners sufficient time to work through the information provided.

The instructions for teachers and candidates that will accompany the Advance Notice article are summarised below:

Notes for guidance (candidates)

1. This leaflet contains an article/s which is needed in preparation for questions in the externally assessed examination H422/02 Scientific literacy in biology.
2. You will need to read the article carefully and also have covered the Learning outcomes for A Level in Biology B (Advancing Biology). The examination paper will contain questions on the article/s. You will be expected to apply your knowledge and understanding of the work covered in A Level in Biology B (Advancing Biology) to answer these questions. There are 20–25 marks available on the question paper for these questions.
3. You can seek advice from your teacher about the content of the article and you can discuss it with others in your class. You may also investigate the topic yourself using any resources available to you.
4. You will not be able to bring your copy of the article, or other materials, into the examination. The examination paper will contain a fresh copy of the article as an insert.
5. You will not have time to read this article for the first time in the examination if you are to complete the examination paper within the specified time. However, you should refer to the article when answering the questions.

Notes for guidance (teachers)

1. This Advance Notice material should be issued to candidates on or after the date shown on the front cover of the candidate instructions sheet at the discretion and convenience of the centre. Candidates can be given the material at any point, but it is suggested that this should be at least four weeks before the examination date.
2. Candidates will need to read the article carefully. Time can be built into the teaching programme to introduce the article content. Candidates should be able to discuss the article freely and be given support and advice in the interpretation of the content so that they are able to answer the questions based on the article in the externally assessed examination. Candidates should also be encouraged to investigate the topics covered in the article for themselves.
3. Candidates will be expected to apply their knowledge and understanding of the content in A Level in Biology B (Advancing Biology) to questions based on the article. There are 20–25 marks available on the paper for these questions.

The Advance Notice material must not be taken into the examination. The examination paper H422/02 will contain a fresh copy of the article, as an insert. Candidates should be reminded that they do not have sufficient time during the examination to read the article for the first time. They should, however, refer to the article printed in the insert in the examination paper to help them to answer the questions.

5f. Health and Safety

In UK law, health and safety is primarily the responsibility of the employer. In a school or college the employer could be a local education authority, the governing body or board of trustees. Employees (teachers/lecturers, technicians etc.), have a legal duty to cooperate with their employer on health and safety matters. Various regulations, but especially the COSHH Regulations 2002 (as amended) and the Management of Health and Safety at Work Regulations 1999, require that before any activity involving a hazardous procedure or harmful microorganisms is carried out, or hazardous chemicals are used or made, the employer must carry out a risk assessment. A useful summary of the requirements for risk assessment in school or college science can be found at http://www.ase.org.uk/resources/health-and-safety-resources/risk-assessments

For members, the CLEAPSS® guide, *PS90, Making and recording risk assessments in school science*[1] offers appropriate advice.

Most education employers have adopted nationally available publications as the basis for their Model Risk Assessments.

Where an employer has adopted model risk assessments an individual school or college then has to review them, to see if there is a need to modify or adapt them in some way to suit the particular conditions of the establishment.

Such adaptations might include a reduced scale of working, deciding that the fume cupboard provision was inadequate or the skills of the candidates were insufficient to attempt particular activities safely. The significant findings of such risk assessment should then be recorded in a "*point of use text*", for example on schemes of work, published teachers guides, work sheets, etc. There is no specific legal requirement that detailed risk assessment forms should be completed for each practical activity, although a minority of employers may require this.

Where project work or investigations, sometimes linked to work-related activities, are included in specifications this may well lead to the use of novel procedures, chemicals or microorganisms, which are not covered by the employer's model risk assessments. The employer should have given guidance on how to proceed in such cases. Often, for members, it will involve contacting CLEAPSS®.

[1] These, and other CLEAPSS® publications, are on the CLEAPSS® Science Publications website www.cleapss.org.uk. Note that CLEAPSS® publications are only available to members. For more information about CLEAPSS® go to www.cleapss.org.uk.

5g. Practical endorsement

The Practical Endorsement is common across Chemistry A and Chemistry B (Salters)/Biology A and Biology B (Advancing Biology) /Physics A and Physics B (Advancing Physics). It requires a minimum of 12 practical activities to be completed from the Practical Activity Groups (PAGs) defined below (**Fig. 1**).

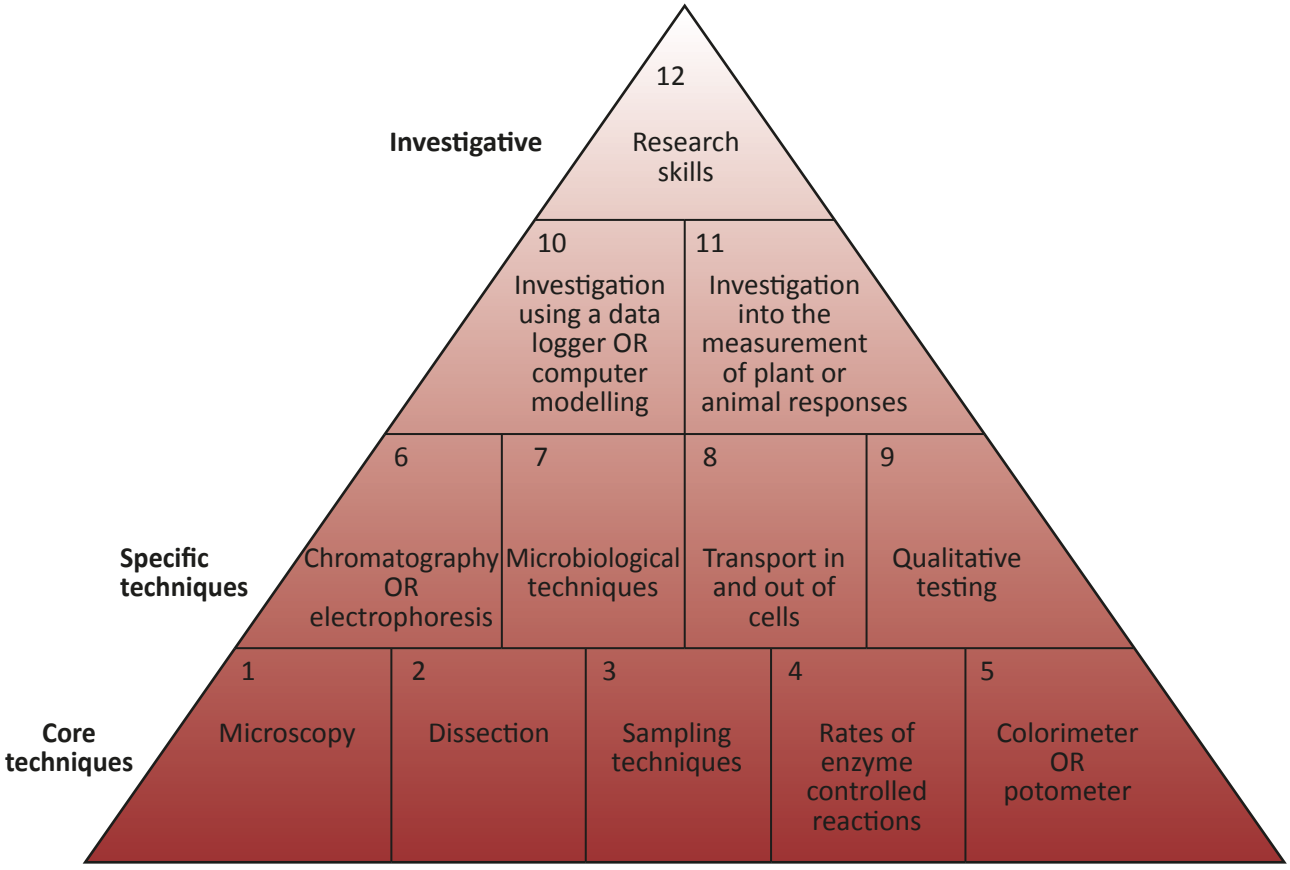

Fig. 1 OCR's Practical Activity Groups (PAGs), also see **Table 1**

Table 1 Practical activity requirements for the OCR Biology Practical Endorsement

Practical activity group (PAG)	Techniques/skills covered (minimum)	Example of a suitable practical activity (a range of examples will be available from the OCR website and centres can devise their own activity)	Specification reference (examples)
1 Microscopy	• Use of a light microscope at high power and low power, use of a graticule[1] • Production of scientific drawings from observations with annotations[2]	Using a light microscope to study mitosis	2.1.1(a) (c) (d) (e) (i), 2.2.3(a), 3.1.1(b), 3.1.2(b), 3.2.3(h), 4.1.2(k), 4.2.1(b), 4.3.1(h), 5.2.1(a), 5.2.2(b), 5.2.3(b), 5.3.2(a), 5.3.3(c)
2 Dissection	• Safe use of instruments for dissection of an animal or plant organ • Use of a light microscope at high power and low power, use of a graticule[1] • Production of scientific drawings from observations with annotations[2]	Dissection of the mammalian heart	2.2.1(a), 2.2.4(c), 5.3.3(b), 4.4.1(b)
3 Sampling techniques	• Use of sampling techniques in fieldwork • Production of scientific drawings from observations with annotations[2]	The calculation of species diversity	4.3.1(m)
4 Rates of enzyme controlled reactions	• Use of appropriate apparatus to record a range of quantitative measurements (to include mass, time, volume, temperature, length and pH)[3] • Use of laboratory glassware apparatus for a variety of experimental techniques to include serial dilutions[4] • Use of ICT such as computer modelling, or data logger to collect data, or use of software to process data [5]	The effect of substrate concentration on the rate of an enzyme controlled reaction	2.1.3(d), 4.3.1(d)

Practical activity group (PAG)	Techniques/skills covered (minimum)	Example of a suitable practical activity (a range of examples will be available from the OCR website and centres can devise their own activity)	Specification reference (examples)
5 Colorimeter OR potometer	• Use of appropriate instrumentation to record quantitative measurements, such as a colorimeter or potometer • Use of laboratory glassware apparatus for a variety of experimental techniques to include serial dilutions[4]	The effect of temperature on membrane permeability	2.1.2(c) (f), 2.2.4(e)
6 Chromatography OR electrophoresis	• Separation of biological compounds using thin layer / paper chromatography or electrophoresis	Identification of the amino acids in a protein using paper chromatography	2.1.3(a), 4.3.1(a), 5.1.3(d)
7 Microbiological techniques	• Use of laboratory glassware apparatus for a variety of experimental techniques to include serial dilutions[4] • Use of microbiological aseptic techniques, including the use of agar plates and broth	The effect of antibiotics on bacterial growth	3.2.3(h)
8 Transport in and out of cells	• Use of appropriate apparatus to record a range of quantitative measurements (to include mass, time, volume, temperature, length and pH)[3] • Use of laboratory glassware apparatus for a variety of experimental techniques to include serial dilutions[4] • Use of ICT such as computer modelling, or data logger to collect data, or use of software to process data[5]	An investigation into the water potential of potato	2.1.1(m), 2.1.2(h)
9 Qualitative testing	• Use of laboratory glassware apparatus for a variety of experimental techniques to include serial dilutions[4] • Use of qualitative reagents to identify biological molecules	Qualitative testing for biological molecules – proteins	2.1.2(c) (f), 5.3.3(c) (f)

Practical activity group (PAG)	Techniques/skills covered (minimum)	Example of a suitable practical activity (a range of examples will be available from the OCR website and centres can devise their own activity)	Specification reference (examples)
10 Investigation using a data logger OR computer modelling	• Use of ICT such as computer modelling, or data logger to collect data, or use of software to process data[5]	Investigating DNA structure using RasMol	2.2.1(e), 2.2.3(c), 4.1.2(d), 5.3.1(e)
11 Investigation into the measurement of plant or animal responses	• Safe and ethical use of organisms to measure plant or animal responses and physiological functions	Investigation into the effect of exercise on pulse rate	2.2.1(e), 2.2.3(c), 4.1.2(d), 5.3.1(e)
12 Research skills	• Apply investigative approaches • Use online and offline research skills • Correctly cite sources of information	Investigation into the respiration rate of *Saccharomyces cerevisiae*	5.2.1(f)

[1,2,3,4,5] These techniques/skills may be covered in any of the groups indicated.

It is expected that the following skills will be developed across all activities, regardless of the exact selection of activities. The ability to:

- safely and correctly use a range of practical equipment and materials **(1.2.1 b)**
- follow written instructions **(1.2.1 c)**
- keep appropriate records of experimental activities **(1.2.1 e)**
- make and record observations/measurements **(1.2.1 d)**
- present information and data in a scientific way **(1.2.1 f)**
- use a wide range of experimental and practical instruments, equipment and techniques **(1.2.1 j)**.

The practical activities can be completed at any point during the two year A level course at the discretion of the centre. Candidates starting from a standalone AS can count A level practical activities carried out during the AS year towards the A level Practical Endorsement provided that they are appropriately recorded. It is recommended therefore that candidates starting AS maintain a record of practical activities carried out (e.g. this could be in the form of a 'log book' or 'practical portfolio') that could be counted towards the Practical Endorsement. For candidates who then decide to follow a full A level, having started from AS, they can carry this record with them into their A level study.

The assessment of practical skills is a compulsory requirement of the course of study for A level qualifications in biology. It will appear on all students' certificates as a separately reported result, alongside the overall grade for the qualification. The arrangements for the assessment of practical skills are common to all awarding organisations. These arrangements include:

- A minimum of 12 practical activities to be carried out by each student which, together, meet the requirements of Appendices 5b (*Practical skills identified for direct assessment and developed through teaching and learning,* covered in Section **1.2.1**) and 5c (*Use of apparatus and techniques*, covered in Section **1.2.2**) from the prescribed subject content, published by the Department for Education. The required practical activities are defined by each awarding organisation (see **Fig. 1** and **Table 1**)
- Teachers will assess students against Common Practical Assessment Criteria (CPAC) issued by the awarding organisations. The CPAC (see **Table 2**) are based on the requirements of Appendices 5b and 5c of the subject content requirements published by the Department for Education, and define the minimum standard required for the achievement of a pass.
- Each student will keep an appropriate record of their practical work, including their assessed practical activities
- Students who demonstrate the required standard across all the requirements of the CPAC, incorporating all the skills, apparatus and techniques (as defined in Sections 1.2.1 and 1.2.2), will receive a 'Pass' grade (note that the practical activity tracker available from OCR allows confirmation that the activities selected cover all the requirements).
- There will be no direct assessment of practical skills for AS qualifications
- Students will answer questions in the AS and A level examination papers that assess the requirements of Appendix 5a (*Practical skills identified for indirect assessment and developed through teaching and learning*, covered in Section **1.1**) from the prescribed subject content, published by the Department for Education. These questions may draw on, or range beyond, the practical activities included in the specification.

In order to achieve a pass, students will need to:

- develop these competencies by carrying out a minimum of 12 practical activities (**PAG1** to **PAG12**), which allow acquisition of all the skills, apparatus and techniques outlined in the requirements of the specification (Sections 1.2.1 and 1.2.2)
- consistently and routinely exhibit the competencies listed in the CPAC (**Table 2**) before the completion of the A-level course
- keep an appropriate record of their practical work, including their assessed practical activities
- be able to demonstrate and/or record independent evidence of their competency, including evidence of independent application of investigative approaches and methods to practical work.

The practical activities prescribed in the subject specification (**PAG1** to **PAG12**) will provide opportunities for demonstrating competence in all the skills identified, together with the use of apparatus and techniques for each subject. However, students can also demonstrate these competencies in any additional practical activity undertaken throughout the course of study which covers the requirements of appendix 5b and 5c (covered in Sections 1.2.1 and 1.2.2).

Students may work in groups but teachers who award a pass to their students need to be confident of individual students' competence.

Table 2 Common Practical Assessment Criteria (CPAC) for the assessment of practical competency in A Level sciences

Competency	Practical Mastery
	In order to be awarded a Pass a Learner must, by the end of the practical science assessment, consistently and routinely meet the criteria in respect of each competency listed below. A Learner may demonstrate the competencies in any practical activity undertaken as part of that assessment throughout the course of study. Learners may undertake practical activities in groups. However, the evidence generated by each Learner must demonstrate that he or she independently meets the criteria outlined below in respect of each competency. Such evidence – **a)** will comprise both the Learner's performance during each practical activity and his or her contemporaneous record of the work that he or she has undertaken during that activity, and **b)** must include evidence of independent application of investigative approaches and methods to practical work.
(1) Follows written procedures	**a)** Correctly follows instructions to carry out experimental techniques or procedures.
(2) Applies investigative approaches and methods when using instruments and equipment	**a)** Correctly uses appropriate instrumentation, apparatus and materials (including ICT) to carry out investigative activities, experimental techniques and procedures with minimal assistance or prompting. **b)** Carries out techniques or procedures methodically, in sequence and in combination, identifying practical issues and making adjustments when necessary. **c)** Identifies and controls significant quantitative variables where applicable, and plans approaches to take account of variables that cannot readily be controlled. **d)** Selects appropriate equipment and measurement strategies in order to ensure suitably accurate results.
(3) Safely uses a range of practical equipment and materials	**a)** Identifies hazards and assesses risks associated with these hazards, making safety adjustments as necessary, when carrying out experimental techniques and procedures in the lab or field. **b)** Uses appropriate safety equipment and approaches to minimise risks with minimal prompting.
(4) Makes and records observations	**a)** Makes accurate observations relevant to the experimental or investigative procedure. **b)** Obtains accurate, precise and sufficient data for experimental and investigative procedures and records this methodically using appropriate units and conventions.
(5) Researches, references and reports	**a)** Uses appropriate software and/or tools to process data, carry out research and report findings. **b)** Cites sources of information, demonstrating that research has taken place, supporting planning and conclusions.

Choice of activity

Centres can include additional skills, apparatus and techniques within an activity (PAG) beyond those listed as the minimum in **Table 1** or in the published practical activities. They may also carry out more than the minimum 12 practical activities required to meet the Practical Endorsement.

To achieve a Pass within the Practical Endorsement, candidates must have demonstrated competence in all the skills, apparatus and techniques detailed in Sections 1.2.1 and 1.2.2 of the specification by carrying out a minimum of 12 assessed practical activities (covering all of **PAG1** to **PAG12**) and achieved the level of competence defined within the Common Practical Assessment Criteria (**Table 2**).

The minimum of 12 activities can be met by:

(i) using OCR suggested activities (provided as resources from Interchange, or by contacting pass@ocr.org.uk should you be unable to access Interchange)

(ii) modifying OCR suggested activities to match available equipment whilst fulfilling the same skills, apparatus and techniques and CPAC

(iii) using activities devised by the centre and mapped against Section 1.2 of the specification and the CPAC

(iv) using activities from external sources such as the learned societies, mapped against Section 1.2 of the specification and the CPAC

Centres can receive guidance on the suitability of their own practical activities or against any of the options within **(ii)** to **(iv)** above through our free practical assessment support service by emailing pass@ocr.org.uk.

Where centres devise their own practical activity or use an alternative activity, that practical activity must be of a level of demand appropriate for A level.

Practical Activity Groups 1 to 12 can be achieved through more than one centre devised practical activity, and centres are not limited to 12 practical activities such that a centre could, for instance, split **PAG8** into two activities of their own (rather than one) with the two activities fulfilling the requirements. Alternatively it could be possible that an extended activity may cover the requirements of more than one group, in which case the centre could then select an additional activity from another group to achieve the required minimum of 12 practical activities.

5h. Revision of the requirements for practical work

OCR will review the Practical Endorsement detailed in Section 5g of this specification following any revision by the Secretary of State of the skills, apparatus or techniques specified in respect of A Level Biology B (Advancing Biology).

OCR will revise the Practical Endorsement if appropriate.

If any revision to the Practical Endorsement is made, OCR will produce an amended specification which will be published on the OCR website. OCR will then use the following methods to communicate the amendment to centres: subject information update emailed sent to all Examinations Officers, e-alerts to centres that have registered to teach the qualification and social media.

Your checklist

Our aim is to provide you with all the information and support you need to deliver our specifications.

- ☐ Bookmark ocr.org.uk/alevelbiologyb for all the latest resources, information and news on AS and A Level Biology B
- ☐ Be among the first to hear about support materials and resources as they become available – register for Biology updates at ocr.org.uk/updates
- ☐ Find out about our professional development at cpdhub.ocr.org.uk
- ☐ View our range of skills guides for use across subjects and qualifications at ocr.org.uk/skillsguides
- ☐ Discover our new online past paper service at ocr.org.uk/exambuilder
- ☐ Learn more about Active Results at ocr.org.uk/activeresults
- ☐ Join our Biology social network community for teachers at social.ocr.org.uk

Download high-quality, exciting and innovative AS and A Level Biology resources from ocr.org.uk/alevelbiologyb

Free resources and support for our A Level Biology qualification, developed through collaboration between our Biology Subject Advisors, teachers and other subject experts, are available from our website. You can also contact our Biology Subject Advisors for specialist advice, guidance and support, giving you individual service and assistance whenever you need it.

Contact the team at:
01223 553998
scienceGCE@ocr.org.uk
@OCR_science

To stay up to date with all the relevant news about our qualifications, register for email updates at ocr.org.uk/updates

Science community

The social network is a free platform where teachers can engage with each other – and with us – to find and offer guidance, discover and share ideas, best practice and a range of Science support materials. To sign up, go to social.ocr.org.uk

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