Unit 4: Energy, Environment, Microbiology and Immunity

IA2 compulsory unit

Externally assessed

Unit description

Introduction	This unit begins with energy capture in photosynthesis and the synthesis of organic compounds by plants, and the flow of energy in ecosystems. This is followed by a consideration of the carbon cycle and how disruption of this cycle may lead to climate change. Students will also consider changes that occur in populations, both in the short term and long term, as a result of mutation and natural selection. The unit continues with an introduction to the diversity and features of microorganisms and how hosts respond to infection by pathogens. This leads to a consideration of the role of microorganisms in decomposition of organic materials and the techniques and applications of polymerase chain reaction (PCR) and gel electrophoresis.
Practical skills	In order to develop their practical skills, students should be encouraged to carry out a range of core practical experiments related to this topic.
Mathematical skills	There are opportunities for the development of mathematical skills in this unit, including tabulation and graphical treatment of data, understanding the principles of sampling, exponential and logarithmic functions and the use of statistics. (Please see *Appendix 6: Mathematical skills and exemplifications* for further information.)

Assessment information

- First assessment: January 2020.
- The assessment is 1 hour and 45 minutes.
- The assessment is out of 90 marks.
- Candidates must answer all questions.
- The paper may include multiple-choice, short-open, open-response, calculations and extended-writing questions.
- The paper will include synoptic questions that may draw on two or more different topics.
- The paper will include a minimum of 9 marks that target mathematics at Level 2 or above.
- Calculators may be used in the examination. Please see *Appendix 8: Use of calculators*.
- Candidates will be expected to apply their knowledge and understanding to familiar and unfamiliar contexts.

Topic 5 – Energy Flow, Ecosystems and the Environment

Candidates will be assessed on their ability to:

5.1	understand the overall reaction of photosynthesis as requiring energy from light to split apart the strong bonds in water molecules, storing the hydrogen in a fuel (glucose) by combining it with carbon dioxide and releasing oxygen into the atmosphere
5.2	understand how photophosphorylation of ADP requires energy and that hydrolysis of ATP provides an immediate supply of energy for biological processes
5.3	understand the light-dependent reactions of photosynthesis, including how light energy is trapped by exciting electrons in chlorophyll and the role of these electrons in generating ATP, reducing NADP in cyclic and non-cyclic photophosphorylation and producing oxygen through photolysis of water
5.4	(i) understand the light-independent reactions as reduction of carbon dioxide using the products of the light-dependent reactions (carbon fixation in the Calvin cycle, the role of GP, GALP, RuBP and RUBISCO) (ii) know that the products are simple sugars that are used by plants, animals and other organisms in respiration and the synthesis of new biological molecules (polysaccharides, amino acids, proteins, lipids and nucleic acids)
5.5	understand the structure of chloroplasts in relation to their role in photosynthesis
5.6	understand what is meant by the terms *absorption spectrum* and *action spectrum*
5.7	understand that chloroplast pigments can be separated using chromatography and the pigments identified using Rf values
5.8	**CORE PRACTICAL 10** **Investigate the effects of light intensity, light wavelength, temperature and availability of carbon dioxide on the rate of photosynthesis using a suitable aquatic plant.**
5.9	(i) understand the relationship between gross primary productivity (GPP), net primary productivity (NPP) and plant respiration (R) (ii) be able to calculate net primary productivity
5.10	know how to calculate the efficiency of biomass and energy transfers between trophic levels
5.11	understand what is meant by the terms *population*, *community*, *habitat* and *ecosystem*
5.12	understand that the numbers and distribution of organisms in a habitat are controlled by biotic and abiotic factors
5.13	understand how the concept of niche accounts for the distribution and abundance of organisms in a habitat

5.14	**CORE PRACTICAL 11** **Carry out a study of the ecology of a habitat, such as using quadrats and transects to determine the distribution and abundance of organisms, and measuring abiotic factors appropriate to the habitat.**
5.15	understand the stages of succession from colonisation to the formation of a climax community
5.16	understand the different types of evidence for climate change and its causes, including records of carbon dioxide levels, temperature records, pollen in peat bogs and dendrochronology, recognising correlations and causal relationships
5.17	understand the causes of anthropogenic climate change, including the role of greenhouse gases in the greenhouse effect
5.18	understand how knowledge of the carbon cycle can be applied to methods to reduce atmospheric levels of carbon dioxide
5.19	(i) understand that data can be extrapolated to make predictions and that these are used in models of future climate change (ii) understand that models for climate change have limitations
5.20	understand the effects of climate change (changing rainfall patterns and changes in seasonal cycles) on plants and animals (distribution of species, development and lifecycles)
5.21	understand the effect of temperature on the rate of enzyme activity and its impact on plants, animals and microorganisms, to include Q_{10}
5.22	**CORE PRACTICAL 12** **Investigate the effects of temperature on the development of organisms (such as seedling growth rate or brine shrimp hatch rates), taking into account the ethical use of organisms.**
5.23	understand how evolution (a change in allele frequency) can come about through gene mutation and natural selection
5.24	understand how isolation reduces gene flow between populations, leading to allopatric or sympatric speciation
5.25	understand the way in which scientific conclusions about controversial issues, such as what actions should be taken to reduce climate change, or the degree to which humans are affecting climate change, can sometimes depend on who is reaching the conclusions
5.26	understand how reforestation and the use of sustainable resources, including biofuels, are examples of the effective management of the conflict between human needs and conservation

Topic 6 – Microbiology, Immunity and Forensics

Candidates will be assessed on their ability to:

6.1	understand the principles and techniques involved in culturing microorganisms, using aseptic technique
6.2	understand the different methods of measuring the growth of microorganisms, as illustrated by cell counts, dilution plating, mass and optical methods (turbidity)
6.3	understand the different phases of a bacterial growth curve (lag phase, exponential phase, stationary phase and death phase) and be able to calculate exponential growth rate constants
6.4	**CORE PRACTIAL 13** **Investigate the rate of growth of microorganisms in a liquid culture, taking into account the safe and ethical use of organisms.**
6.5	(i) be able to compare the structure of bacteria and viruses (nucleic acid, capsid structure and envelope) with reference to Ebola virus, tobacco mosaic virus (TMV), human immunodeficiency virus (HIV) and lambda phage (λ phage) (ii) understand what is meant by the terms *lytic* and *latency*
6.6	understand how *Mycobacterium tuberculosis* and human immunodeficiency virus (HIV) infect human cells, causing symptoms that may result in death
6.7	(i) know the major routes pathogens may take when entering the body (ii) understand the role of barriers in protecting the body from infection, including skin, stomach acid, and gut and skin flora
6.8	understand the non-specific responses of the body to infection, including inflammation, lysozyme action, interferon and phagocytosis
6.9	understand the roles of antigens and antibodies in the body's immune response including the involvement of plasma cells, macrophages and antigen-presenting cells
6.10	understand the differences between the roles of B cells (B memory and B effector cells), and T cells (T helper, T killer and T memory cells) in the host's immune response
6.11	understand how individuals may develop immunity (natural, artificial, active and passive)
6.12	understand how the theory of an 'evolutionary race' between pathogens and their hosts is supported by evasion mechanisms shown by pathogens
6.13	understand the difference between bacteriostatic and bactericidal antibiotics
6.14	**CORE PRACTICAL 14** **Investigate the effect of different antibiotics on bacteria.**
6.15	know how an understanding of the contributory causes of hospital-acquired infections has led to codes of practice regarding antibiotic prescription and hospital practice that relate to infection prevention and control

6.16	know the role of microorganisms in the decomposition of organic matter and the recycling of carbon
6.17	know how DNA can be amplified using the polymerase chain reaction (PCR)
6.18	know how gel electrophoresis can be used to separate DNA fragments of different length
6.19	understand how DNA profiling is used for identification and determining genetic relationships between organisms (plants and animals)
6.20	understand how to determine the time of death of a mammal by examining the extent of decomposition, stage of succession, forensic entomology, body temperature and degree of muscle contraction

Assessment information

Assessment requirements

The Pearson Edexcel International Advanced Subsidiary in Biology consists of three externally examined units.

The Pearson Edexcel International Advanced Level in Biology consists of six externally examined units.

Candidates must complete all assessments.

Please see the *Assessment availability and first award* section for information on from when the assessment for each unit will be available.

Unit	IAS or IA2	Assessment information	Number of raw marks allocated in the unit
Unit 1: Molecules, Diet, Transport and Health	IAS	Externally assessed Written examination: 1 hour and 30 minutes Availability: January, June and October First assessment: January 2019	80 marks
Unit 2: Cells, Development, Biodiversity and Conservation	IAS	Externally assessed Written examination: 1 hour and 30 minutes Availability: January, June and October First assessment: June 2019	80 marks
Unit 3: Practical Skills in Biology I	IAS	Externally assessed Written examination: 1 hour and 20 minutes Availability: January, June and October First assessment: June 2019	50 marks

Unit	IAS or IA2	Assessment information	Number of raw marks allocated in the unit
Unit 4: Energy, Environment, Microbiology and Immunity	IA2	Externally assessed Written examination: 1 hour and 45 minutes Availability: January, June and October First assessment: January 2020	90 marks
Unit 5: Respiration, Internal Environment, Coordination and Gene Technology	IA2	Externally assessed Written examination: 1 hour and 45 minutes Availability: January, June and October First assessment: June 2020	90 marks
Unit 6: Practical Skills in Biology II	IA2	Externally assessed Written examination: 1 hour and 20 minutes Availability: January, June and October First assessment: June 2020	50 marks

Sample assessment materials

Sample papers and mark schemes can be found in the *Pearson Edexcel International Advanced Subsidiary/Advanced Level in Biology Sample Assessment Materials (SAMs)* document.

A full list of command words that will be used in the assessment across the IAS/IAL Science qualifications can be found in *Appendix 7: Taxonomy*.

Assessment objectives and weightings

		% in IAS	% in IA2	% in IAL
AO1	Demonstrate knowledge and understanding of science	36–39	31–34	34–37
AO2	(a) Application of knowledge and understanding of science in familiar and unfamiliar contexts.	34–36	33–36	33–36
	(b) Analysis and evaluation of scientific information to make judgments and reach conclusions.	9–11	14–16	11–14
AO3	Experimental skills in science, including analysis and evaluation of data and methods	17–18	17–18	17–18

Relationship of assessment objectives to units for the International Advanced Subsidiary qualification

Unit number	Assessment objective (%)			
	AO1	AO2a	AO2b	AO3
Unit 1	17–18	17–18	4.5–5.5	0
Unit 2	17–18	17–18	4.5–5.5	0
Unit 3	2–3	0	0	17–18
Total for International Advanced Subsidiary	36–39	34–36	9–11	17–18

Relationship of assessment objectives to units for the International Advanced Level qualification

Unit number	Assessment objective (%)			
	AO1	AO2a	AO2b	AO3
Unit 1	8.5–9.0	8.5–9.0	2.2–2.8	0
Unit 2	8.5–9.0	8.5–9.0	2.2–2.8	0
Unit 3	1–1.5	0	0	8.8–9.2
Unit 4	7.3–7.8	8.4–8.9	3.6–4.0	0
Unit 5	7.3–7.8	8.4–8.9	3.6–4.0	0
Unit 6	1–1.5	0	0	8.8–9.2
Total for International Advanced Level	34–37	33–36	11–14	17–18

Assessment availability and first award

Unit	January 2019	June 2019	October 2019	January 2020	June 2020
1	✓	✓	✓	✓	✓
2	×	✓	✓	✓	✓
3	×	✓	✓	✓	✓
4	×	×	×	✓	✓
5	×	×	×	×	✓
6	×	×	×	×	✓
IAS award	×	✓	✓	✓	✓
IAL award	×	×	×	×	✓

From June 2020, **all six units will be assessed** in January, June and October for the lifetime of the qualification.

From June 2020, **IAL and IAS will both be awarded** in January, June and October for the lifetime of the qualification.

Administration and general information

Entries and resitting of units

Entries

Details of how to enter students for the examinations for these qualifications can be found in our *International Information Manual*. A copy is made available to all examinations officers and is available on our website, qualifications.pearson.com.

Resitting of units

Candidates can resit any unit irrespective of whether the qualification is to be cashed in. If a candidate resits a unit more than once, only the better of the two most recent attempts of that unit will be available for aggregation to a qualification grade.

Access arrangements, reasonable adjustments, special consideration and malpractice

Equality and fairness are central to our work. Our equality policy requires all students to have equal opportunity to access our qualifications and assessments, and our qualifications to be awarded in a way that is fair to every student.

We are committed to making sure that:

- students with a protected characteristic (as defined by the UK Equality Act 2010) are not, when they are undertaking one of our qualifications, disadvantaged in comparison to students who do not share that characteristic
- all students achieve the recognition they deserve for undertaking a qualification and that this achievement can be compared fairly to the achievement of their peers.

Language of assessment

Assessment of these qualifications will be available in English only. All student work must be in English.

We recommend that students are able to read and write in English at Level B2 of the Common European Framework of Reference for Languages.

Access arrangements

Access arrangements are agreed before an assessment. They allow candidates with special educational needs, disabilities or temporary injuries to:

- access the assessment
- show what they know and can do without changing the demands of the assessment.

The intention behind an access arrangement is to meet the particular needs of an individual candidate with a disability without affecting the integrity of the assessment. Access arrangements are the principal way in which awarding bodies comply with the duty under the Equality Act 2010 to make 'reasonable adjustments'.

Access arrangements should always be processed at the start of the course. Students will then know what is available and have the access arrangement(s) in place for assessment.

Reasonable adjustments

The Equality Act 2010 requires an awarding organisation to make reasonable adjustments where a student with a disability would be at a substantial disadvantage in undertaking an assessment. The awarding organisation is required to take reasonable steps to overcome that disadvantage.

A reasonable adjustment for a particular student may be unique to that individual and therefore might not be in the list of available access arrangements.

Whether an adjustment will be considered reasonable will depend on a number of factors, including:

- the needs of the student with the disability
- the effectiveness of the adjustment
- the cost of the adjustment
- the likely impact of the adjustment on the student with the disability and other students.

An adjustment will not be approved if it involves unreasonable costs to the awarding organisation, timeframes or affects the security or integrity of the assessment. This is because the adjustment is not 'reasonable'.

Special consideration

Special consideration is a post-examination adjustment to a candidate's mark or grade to reflect temporary injury, illness or other indisposition at the time of the examination/assessment, which has had, or is reasonably likely to have had, a material effect on a candidate's ability to take an assessment or demonstrate their level of attainment in an assessment.

Further information

Please see our website for further information about how to apply for access arrangements and special consideration.

For further information about access arrangements, reasonable adjustments and special consideration please refer to the JCQ website: www.jcq.org.uk.

Candidate malpractice

Candidate malpractice refers to any act by a candidate that compromises or seeks to compromise the process of assessment, or which undermines the integrity of the qualifications or the validity of results/certificates.

Candidate malpractice in examinations **must** be reported to Pearson using a *JCQ Form M1* (available at www.jcq.org.uk/exams-office/malpractice). The form should be emailed to candidatemalpractice@pearson.com. Please provide as much information and supporting documentation as possible. Note that the final decision regarding appropriate sanctions lies with Pearson.

Failure to report malpractice constitutes staff or centre malpractice.

Staff/centre malpractice

Staff and centre malpractice includes both deliberate malpractice and maladministration of our qualifications. As with candidate malpractice, staff and centre malpractice is any act that compromises or seeks to compromise the process of assessment, or which undermines the integrity of the qualifications or the validity of results/certificates.

All cases of suspected staff malpractice and maladministration **must** be reported immediately, before any investigation is undertaken by the centre, to Pearson on a *JCQ Form M2(a)* (available at www.jcq.org.uk/exams-office/malpractice).

The form, supporting documentation and as much information as possible should be emailed to pqsmalpractice@pearson.com. Note that the final decision regarding appropriate sanctions lies with Pearson.

Failure to report malpractice itself constitutes malpractice.

More detailed guidance on malpractice can be found in the latest version of the document *Suspected Malpractice in Examinations and Assessments Policies and Procedures* available at www.jcq.org.uk/exams-office/malpractice.

Awarding and reporting

The Pearson Edexcel International Advanced Subsidiary in Biology will be graded on a five-grade scale from A to E. The Pearson Edexcel International Advanced Level in Biology will be graded on a six-point scale from A* to E. Individual unit results will be reported. Only units 1, 2 and 3 will contribute to the International Advanced Subsidiary grade. All six units will contribute to the International Advanced Level grade.

The first certification opportunity for the Pearson Edexcel International Advanced Subsidiary in Biology will be in August 2019. The first certification opportunity for the Pearson Edexcel International Advanced Level in Biology will be in August 2020.

A pass in an International Advanced Subsidiary subject is indicated by one of the five grades A, B, C, D, E, of which grade A is the highest and grade E the lowest.

A pass in an International Advanced Level subject is indicated by one of the six grades A*, A, B, C, D, E, of which grade A* is the highest and grade E the lowest.

Candidates whose level of achievement is below the minimum judged by Pearson to be of sufficient standard to be recorded on a certificate will receive an unclassified U result.

Unit results

Candidates will receive a uniform mark between 0 and the maximum uniform mark for each unit.

The uniform marks at each grade threshold for each unit are:

Units 1, 2, 4 and 5

Unit grade	**Maximum uniform mark**	**A**	**B**	**C**	**D**	**E**
	120	**96**	**84**	**72**	**60**	**48**

Units 3 and 6

Unit grade	**Maximum uniform mark**	**A**	**B**	**C**	**D**	**E**
	60	**48**	**42**	**36**	**30**	**24**

Qualification results

The minimum uniform marks required for each grade:

International Advanced Subsidiary (cash-in code: XBI11)

Qualification grade	**Maximum uniform mark**	**A**	**B**	**C**	**D**	**E**
	300	**240**	**210**	**180**	**150**	**120**

Candidates with a uniform mark in the range 0–119 will be Unclassified (U).

International Advanced Level (cash-in code: YBI11)

Qualification grade	**Maximum uniform mark**	**A**	**B**	**C**	**D**	**E**
	600	**480**	**420**	**360**	**300**	**240**

Candidates with a uniform mark in the range 0–239 will be Unclassified (U).

To be awarded an A*, candidates will need to achieve an A for the International Advanced Level qualification (at least 480 uniform marks) **and** at least 90 percent of the total uniform marks available across the IA2 units combined (at least 270 uniform marks).

Student recruitment and progression

Pearson follows the Joint Council for Qualifications (JCQ) policy concerning recruitment to our qualifications in that:

- they must be available to anyone who is capable of reaching the required standard
- they must be free from barriers that restrict access and progression
- equal opportunities exist for all students.

Prior learning and other requirements

Students who would benefit most from studying these qualifications are likely to have a Level 2 qualification such as a GCSE or International GCSE in Biology.

Progression

Students can progress from these qualifications to:

- a range of different, relevant academic or vocational higher education qualifications; for example, a degree in biology or in a related subject, including marine biology, natural science and anatomy, or equivalent qualifications such as BTEC Higher Nationals
- employment
- further training.

Appendices

Appendix 1: Codes

Type of code	Use of code	Code
Unit codes	Each unit is assigned a unit code. This unit code is used as an entry code to indicate that a student wishes to take the assessment for that unit. Centres will need to use the entry codes only when entering students for their examination.	Unit 1: WBI11/01 Unit 2: WBI12/01 Unit 3: WBI13/01 Unit 4: WBI14/01 Unit 5: WBI15/01 Unit 6: WBI16/01
Cash-in codes	The cash-in code is used as an entry code to aggregate the student's unit scores to obtain the overall grade for the qualification. Centres will need to use the entry codes only when entering students for their qualification.	International Advanced Subsidiary – XBI11 International Advanced Level – YBI11
Entry codes	The entry codes are used to: • enter a student for the assessment of a unit • aggregate the student's unit scores to obtain the overall grade for the qualification.	Please refer to the *Pearson Information Manual*, available on our website.

Appendix 2: Pearson World Class Qualification design principles

Pearson's World Class Qualification design principles mean that all Pearson Edexcel qualifications are developed to be **rigorous, demanding, inclusive and empowering**.

We work collaboratively to gain approval from an external panel of educational thought leaders and assessment experts from across the globe. This is to ensure that Pearson Edexcel qualifications are globally relevant, represent world-class best practice in qualification and assessment design, maintain a consistent standard and support learner progression in today's fast-changing world.

Pearson's Expert Panel for World-Class Qualifications is chaired by Sir Michael Barber, a leading authority on education systems and reform. He is joined by a wide range of key influencers with expertise in education and employability.

"I'm excited to be in a position to work with the global leaders in curriculum and assessment to take a fresh look at what young people need to know and be able to do in the 21st century, and to consider how we can give them the opportunity to access that sort of education." Sir Michael Barber.

Endorsement from Pearson's Expert Panel for World Class Qualifications for the International Advanced Subsidiary (IAS)/International Advanced Level (IAL) development process

May 2014

"We were chosen, either because of our expertise in the UK education system, or because of our experience in reforming qualifications in other systems around the world as diverse as Singapore, Hong Kong, Australia and a number of countries across Europe.

We have guided Pearson through what we judge to be a rigorous world class qualification development process that has included:

- extensive international comparability of subject content against the highest-performing jurisdictions in the world
- benchmarking assessments against UK and overseas providers to ensure that they are at the right level of demand
- establishing External Subject Advisory Groups, drawing on independent subject-specific expertise to challenge and validate our qualifications.

Importantly, we have worked to ensure that the content and learning is future oriented, and that the design has been guided by Pearson's Efficacy Framework. This is a structured, evidenced process which means that learner outcomes have been at the heart of this development throughout.

We understand that ultimately it is excellent teaching that is the key factor to a learner's success in education but as a result of our work as a panel we are confident that we have supported the development of Edexcel IAS and IAL qualifications that are outstanding for their coherence, thoroughness and attention to detail and can be regarded as representing world-class best practice."

Sir Michael Barber (Chair)
Chief Education Advisor, Pearson plc

Dr Peter Hill
Former Chief Executive ACARA

Professor Jonathan Osborne
Stanford University

Professor Dr Ursula Renold
Federal Institute of Technology, Switzerland

Professor Janice Kay
Provost, University of Exeter

Jason Holt
CEO, Holts Group

Professor Lee Sing Kong
Dean and Managing Director, National Institute of Education International, Singapore

Bahram Bekhradnia
President, Higher Education Policy Institute

Dame Sally Coates
Director of Academies (South), United Learning Trust

Professor Bob Schwartz
Harvard Graduate School of Education

Jane Beine
Head of Partner Development, John Lewis Partnership

All titles correct as at May 2014

Appendix 3: Transferable skills

The need for transferable skills

In recent years, higher-education institutions and employers have consistently flagged the need for students to develop a range of transferable skills to enable them to respond with confidence to the demands of undergraduate study and the world of work.

The Organisation for Economic Cooperation and Development (OECD) defines skills, or competencies, as 'the bundle of knowledge, attributes and capacities that can be learned and that enable individuals to successfully and consistently perform an activity or task and can be built upon and extended through learning.'[1]

To support the design of our qualifications, the Pearson Research Team selected and evaluated seven global 21st-century skills frameworks. Following on from this process, we identified the National Research Council's (NRC) framework [2] as the most evidence-based and robust skills framework, and have used this as a basis for our adapted skills framework.

The framework includes cognitive, intrapersonal skills and interpersonal skills.

The skills have been interpreted for this specification to ensure they are appropriate for the subject. All of the skills listed are evident or accessible in the teaching, learning and/or assessment of the qualifications. Some skills are directly assessed. Pearson materials will support you in identifying these skills and developing these skills in students.

The table overleaf sets out the framework and gives an indication of the skills that can be found in Biology and indicates the interpretation of the skill in this area. A full subject interpretation of each skill, with mapping to show opportunities for student development is given on the subject pages of our website: qualifications.pearson.com

[1] OECD – *Better Skills, Better Jobs, Better Lives* (OECD Publishing, 2012)
[2] Koenig J A, National Research Council – *Assessing 21st Century Skills: Summary of a Workshop* (National Academies Press, 2011)

Cognitive skills	Cognitive processes and strategies	• Critical thinking • Problem solving • Analysis • Reasoning/argumentation • Interpretation • Decision making • Adaptive learning • Executive function
	Creativity	• Creativity • Innovation
Intrapersonal skills	Intellectual openness	• Adaptability • Personal and social responsibility • Continuous learning • Intellectual interest and curiosity
	Work ethic/ conscientiousness	• Initiative • Self-direction • Responsibility • Perseverance • Productivity • Self-regulation (metacognition, forethought, reflection) • Ethics • Integrity
	Positive core self-evaluation	• Self-monitoring/ self-evaluation/ self-reinforcement
Interpersonal skills	Teamwork and collaboration	• Communication • Collaboration • Teamwork • Cooperation • Empathy/perspective taking • Negotiation
	Leadership	• Responsibility • Assertive communication • Self-presentation

Evaluate evidence related to biology and then bring it together to form a conclusion.

Taking responsibility for carrying out practical work in a safe manner, following all safety requirements.

Work with other students in practical work, so that the contribution of every student is encouraged and valued.

Appendix 4: Level 3 Extended Project qualification

What is the Extended Project?

The Extended Project is a stand-alone qualification that can be taken alongside International Advanced Level (IAL) qualifications. It supports the development of independent learning skills and helps to prepare students for their next step – whether that be higher education or employment. The qualification:

- is recognised by higher education institutions for the skills it develops
- is worth half of an International Advanced Level (IAL) qualification at grades A*–E
- carries UCAS points for university entry.

The Extended Project encourages students to develop skills in the following areas: research, critical thinking, extended writing and project management. Students identify and agree a topic area of their choice for in-depth study (which may or may not be related to an IAL subject they are already studying), guided by their teacher.

Students can choose from one of four approaches to produce:

- a dissertation (for example, an investigation based on predominately secondary research)
- an investigation/field study (for example, a practical experiment)
- a performance (for example, in music, drama or sport)
- an artefact (for example, creating a sculpture in response to a client brief or solving an engineering problem).

The qualification non-examined assessment-based and students are assessed on the skills of managing, planning and evaluating their project. Students will research their topic, develop skills to review and evaluate the information, and then present the final outcome of their project.

The Extended Project has 120 guided learning hours (GLH) consisting of a 40-GLH taught element that includes teaching the technical skills (for example, research skills) and an 80-GLH guided element that includes mentoring students through the project work. The qualification is 100% internally assessed and externally moderated.

How to link the Extended Project with biology

The Extended Project creates the opportunity to develop transferable skills for progression to higher education and to the workplace through the exploration of either an area of personal interest or a topic of interest from within the biology qualification content.

Through the Extended Project, students will develop skills that support their study of biology, including:

- conducting, organising and using research
- independent reading in the subject area
- planning, project management and time management
- stating a proposal to be tested in investigations
- collecting, handling and interpreting data and evidence
- evaluating arguments and processes, including arguments in favour of alternative interpretations of data and evaluation of experimental methodology
- critical thinking.

In the context of the Extended Project, critical thinking refers to the ability to identify and develop arguments for a point of view or hypothesis and to consider and respond to alternative arguments.

Types of Extended Project related to biology

Students may produce a dissertation on any topic that can be researched and argued. A dissertation might involve an investigation such as:

- Is it ethical to use stem cells for medical purposes?
- Should restrictions be placed on research into genetic enhancement?
- Is the use of animal experimentation justifiable?

The dissertation uses secondary research sources to provide a reasoned defence or a point of view, with consideration of counter-arguments.

An alternative might be an investigative project or field study involving the collection of data from primary research, for example:

- Can changing owl behaviour be monitored through pellet studies?
- How has marina development affected local marshland biodiversity?
- Can pollution be effectively monitored by water quality in a local stream?

There is also scope for biology-based artefact Extended Projects. For example, a student might set out to design, make and test an item of apparatus. Extended Projects involving a performance can also be biology based. For example, a social issue relating to biology could be explored through drama.

Using the Extended Project to support breadth and depth

In the Extended Project, students are assessed on the quality of the work they produce and the skills they develop and demonstrate through completing this work. Students should demonstrate that they have extended themselves in some significant way beyond what they have been studying in biology. Students can demonstrate extension in one or more dimensions:

- ***deepening understanding*** – where a student explores a topic in greater depth than in the specification content.
- ***broadening skills*** – where a student learns a new skill. In a biology-based project, this might involve learning to assemble and manipulate an unfamiliar piece of apparatus or learning advanced data-handling techniques.
- ***widening perspectives*** – where the student's project spans different subjects. This might involve discussing historical, philosophical or ethical aspects of a biology-based topic or making links with other subject areas such as chemistry or geography.

A wide range of information to support the delivery and assessment of the Extended Project, including the specification, teacher guidance for all aspects, an editable scheme of work and exemplars for all four approaches, can be found on our website.

Appendix 5: Glossary

Term	Definition
Assessment objectives	The requirements that students need to meet to succeed in the qualification. Each assessment objective has a unique focus, which is then targeted in examinations or coursework. Assessment objectives may be assessed individually or in combination.
External assessment	An examination that is held at the same time and place in a global region.
International Advanced Subsidiary	Abbreviated to IAS.
International Advanced Level	Abbreviated to IAL.
International A2 (IA2)	The additional content required for an IAL.
Linear	Linear qualifications have all assessments at the end of a course of study. The final qualification grade is worked out from the combined unit results.
Modular	Modular qualifications contain units of assessment. These units can be taken during the course of study. The final qualification grade is worked out from the combined unit results.
Non-examined assessment (NEA)	This is any assessment that is not sat in examination conditions at a fixed time and place. It includes coursework, oral examinations and practical examinations.
Raw marks	Raw marks are the actual marks that students achieve when taking an assessment. When calculating an overall grade, raw marks often need to be converted so that it is possible to see the proportionate achievement of a student across all units of study.
Uniform Mark Scale (UMS)	Candidate's actual marks (or raw marks) will be converted into a UMS mark so that it is possible to see the proportionate result of a candidate. Two units may each be worth 25 percent of a total qualification. The raw marks for each unit may differ, but the uniform mark will be the same.
Unit	A modular qualification will be divided into a number of units. Each unit will have its own assessment.

Appendix 6: Mathematical skills and exemplifications

In order to be able to develop their skills, knowledge and understanding in biology, students need to have been taught, and to have acquired competence in, the appropriate areas of mathematics relevant to the subject as indicated in the table on the following pages[3].

The assessment of quantitative skills will include at least 10 percent Level 2 or above mathematical skills. These skills will be applied in the context of biology.

All mathematical content will be assessed within the lifetime of the qualifications.

The following tables illustrate where these mathematical skills may be developed and could be assessed. Those shown in bold type would only be tested in the full International Advanced Level course.

This list of examples is not exhaustive. These skills could be developed in other areas of specification content.

[3] The information in this appendix has been taken directly from the document *GCE AS and A level regulatory requirements for biology, chemistry, physics and psychology* published by the Department for Education (April 2014).

	Mathematical skills	Exemplification of mathematical skill in the context of A Level biology (assessment is not limited to the examples given below)
(i) A.0 – arithmetic and numerical computation		
A.0.1	Recognise and make use of appropriate units in calculations	Candidates 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.
A.0.2	Recognise and use expressions in decimal and standard form	Candidates 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 • 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}.
A.0.3	Use ratios, fractions and percentages	Candidates may be tested on their ability to: • calculate percentage yields • calculate surface area to volume ratio • use scales for measuring • represent phenotypic (monohybrid and dihybrid crosses).
A.0.4	Estimate results	Candidates may be tested on their ability to: • estimate results to sense check that the calculated values are appropriate.
A.0.5	**Use calculators to find and use power, exponential and logarithmic functions**	**Candidates may be tested on their ability to:** • **estimate the number of bacteria grown over a certain length of time.**

	Mathematical skills	Exemplification of mathematical skill in the context of A Level biology (assessment is not limited to the examples given below)
(ii) A.1 – handling data		
A.1.1	Use an appropriate number of significant figures	Candidates 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 be reported only to the limits of the least accurate measurement.
A.1.2	Find arithmetic means	Candidates 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.
A.1.3	Construct and interpret frequency tables and diagrams, bar charts and histograms	Candidates 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.
A.1.4	Understand simple probability	Candidates may be tested on their ability to: • use the terms probability and chance appropriately • understand the probability associated with genetic inheritance.
A.1.5	Understand the principles of sampling as applied to scientific data	Candidates may be tested on their ability to: • analyse random data collected by an appropriate means, e.g. calculate an index of diversity to compare the biodiversity of a habitat.
A.1.6	Understand the terms mean, median and mode	Candidates 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.

	Mathematical skills	Exemplification of mathematical skill in the context of A Level biology (assessment is not limited to the examples given below)
(ii) A.1 — handling data (continued)		
A.1.7	Use a scatter diagram to identify a correlation between two variables	Candidates may be tested on their ability to: • interpret a scattergram, e.g. the effect of life style factors on health.
A.1.8	Make order of magnitude calculations	Candidates may be tested on their ability to: • use and manipulate the magnification formula magnification = $\frac{\text{size of image}}{\text{size of real object}}$
A.1.9	Select and use a statistical test	Candidates may be tested on their ability to select and use: • the chi-squared test to test the significance of the difference between observed and expected results • the Student's t-test • the correlation coefficient.
A.1.10	Understand measures of dispersion, including standard deviation and range	Candidates 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.
A.1.11	Identify uncertainties in measurements and use simple techniques to determine uncertainty when data are combined	Candidates may be tested on their ability to: • calculate percentage error where there are uncertainties in measurement.
(iii) A.2 – algebra		
A.2.1	Understand and use the symbols: =, <, <<, >>, >, ∝, ~.	No exemplification required.
A.2.2	Change the subject of an equation	Candidates may be tested on their ability to: • use and manipulate equations, e.g. magnification.
A.2.3	Substitute numerical values into algebraic equations using appropriate units for physical quantities	Candidates may be tested on their ability to: • use a given equation e.g. a formula to calculate an index of diversity $D = \frac{N(N-1)}{\Sigma n(n-1)}$

	Mathematical skills	Exemplification of mathematical skill in the context of A Level biology (assessment is not limited to the examples given below)
A.2.4	Solve algebraic equations	Candidates may be tested on their ability to: • solve equations in a biological context, e.g. cardiac output = stroke volume x heart rate.
A.2.5	**Use logarithms in relation to quantities that range over several orders of magnitude**	**Candidates 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.**
(iv) A.3 – graphs		
A.3.1	Translate information between graphical, numerical and algebraic forms	Candidates 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.
A.3.2	Plot two variables from experimental or other data	Candidates may be tested on their ability to: • select an appropriate format for presenting data, bar charts, histograms, graphs and scattergrams.
A.3.3	Understand that $y = mx + c$ represents a linear relationship	Candidates 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.
A.3.4	**Determine the intercept of a graph**	**Candidates may be tested on their ability to:** • **read off an intercept point from a graph, e.g. compensation point in plants.**
A.3.5	Calculate rate of change from a graph showing a linear relationship	Candidates may be tested on their ability to: • calculate a rate from a graph, e.g. rate of transpiration.
A.3.6	Draw and use the slope of a tangent to a curve as a measure of rate of change	Candidates 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.

	Mathematical skills	Exemplification of mathematical skill in the context of A Level biology (assessment is not limited to the examples given below)
(v) A.4 – geometry and trigonometry		
A.4.1	Calculate the circumferences, surface areas and volumes of regular shapes	Candidates 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.

Appendix 7: Taxonomy

The following table lists the command words used across the IAS/IAL Science qualifications in the external assessments.

Command word	Definition
Add/Label	Requires the addition or labelling to stimulus material given in the question, for example: labelling a diagram or adding units to a table.
Assess	Give careful consideration to all the factors or events that apply and identify which are the most important or relevant. Make a judgement on the importance of something, and come to a conclusion where needed.
Calculate	Obtain a numerical answer, showing relevant working. If the answer has a unit, this must be included.
Comment on	Requires the synthesis of a number of factors from data/information to form a judgement. More than two factors need to be synthesised.
Compare and contrast	Look for the similarities **and** differences of two (or more) things. Should not require the drawing of a conclusion. Answer must relate to both (or all) things mentioned in the question. The answer must include at least one similarity and one difference.
Complete/Record	Requires the completion of a table/diagram/equation.
Criticise	Inspect a set of data, an experimental plan or a scientific statement and consider the elements. Look at the merits and/or faults of the information presented and back judgements made.
Deduce	Draw/reach conclusion(s) from the information provided.
Derive	Combine two or more equations or principles to develop a new equation.
Describe	Give an account of something. Statements in the response need to be developed as they are often linked but do not need to include a justification or reason.
Determine	The answer must have an element which is quantitative from the stimulus provided, or must show how the answer can be reached quantitatively.
Devise	Plan or invent a procedure from existing principles/ideas.
Discuss	Identify the issue/situation/problem/argument that is being assessed within the question. Explore all aspects of an issue/situation/problem. Investigate the issue/situation/problem etc. by reasoning or argument.
Draw	Produce a diagram either using a ruler or freehand.

Command word	Definition
Estimate	Give an approximate value for a physical quantity, or measurement, or uncertainty.
Evaluate	Review information, then bring it together to form a conclusion, drawing on evidence including strengths, weaknesses, alternative actions, relevant data or information. Come to a supported judgement of a subject's qualities and relation to its context.
Explain	An explanation requires a justification/exemplification of a point. The answer must contain some element of reasoning/justification, this can include mathematical explanations.
Give/State/Name	All of these command words are really synonyms. They generally all require a recall of one or more pieces of information.
Give a reason/reasons	When a statement has been made and the requirement is only to give the reasons why.
Identify	Usually requires some key information to be selected from a given stimulus/resource.
Justify	Give evidence to support (either the statement given in the question or an earlier answer).
Plot	Produce a graph by marking points accurately on a grid from data that is provided and then drawing a line of best fit through these points. A suitable scale and appropriately labelled axes must be included if these are not provided in the question.
Predict	Give an expected result or outcome.
Show that	Prove that a numerical figure is as stated in the question. The answer must be to at least one more significant figure than the numerical figure in the question.
Sketch	Produce a freehand drawing. For a graph, this would need a line and labelled axes with important features indicated; the axes are not scaled.
State what is meant by	When the meaning of a term is expected but there are different ways of how these can be described.
Suggest	Use your knowledge and understanding in an unfamiliar context. May include material or ideas that have not been learnt directly from the specification.
Write	When the questions ask for an equation.

Appendix 8: Use of calculators

Candidates may use a calculator in the assessments for these qualifications. Centres are responsible for making sure that calculators used by their students meet the requirements given in the table below.

Candidates must be familiar with the requirements before their assessments for these qualifications.

<table>
<tr>
<td>Calculators must be:
of a size suitable for use on a desk
either battery- or solar-powered
free of lids, cases and covers that contain printed instructions or formulae.</td>
<td rowspan="2">Calculators must not:
be designed or adapted to offer any of these facilities:
language translators
symbolic algebraic manipulation
symbolic differentiation or integration
communication with other machines or the internet
be borrowed from another candidate during an examination for any reason*
have retrievable information stored in them. This includes:
databanks
dictionaries
mathematical formulae
text.</td>
</tr>
<tr>
<td>The candidate is responsible for the following:
the calculator’s power supply
the calculator’s working condition
clearing anything stored in the calculator.</td>
</tr>
</table>

*An invigilator may give a candidate a calculator.

Further information can be found in the JCQ documents *Instructions for conducting examinations* and *Information for candidates – written exams*, available at www.jcq.org.uk/exams-office.

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