Practical and Transferable Skills in Pearson International GCSE, AS & A Level Biology

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John Fallon,
Chief Executive Officer, Pearson

Agenda for Day 2

9.00 Welcome and Introduction

9.15 Core Practicals and Practical Assessment

10.30 Break

11.00 General Practical Assessment (AO3)

12.30 Lunch

13.30 Mathematical and Transferable Skills

15.00 Break

15.30 Transferable skills in the classroom and sharing good practice

17.00 Finish

Welcome and Introduction

Aims of the Day

- To review practical assessment
- To explore methods of delivering Assessment Objective 3 (AO3)
- To explore how to develop transferable skills through biology.

Core Practicals and Practical Assessment

How is Practical Work Assessed in Science Qualifications?

International GCSEs

- No separate practical assessments
- No separate written practical exam
- No coursework or teacher assessment
- Practical skills are assessed on the exam papers as part of AO3
- Core Practicals - it is expected candidates will have experience of these

International AS and A Level

- Unit 3 and Unit 6 assess practical skills
- No coursework or teacher assessment
- Core Practicals - it is expected candidates will have experienced

Core Practicals and General Practical Skills

Core Practicals

- All courses have a series of core practicals that candidates should complete.
- Candidates may be tested on their knowledge of these practicals.
- Questions about modified versions of the core practicals can be set.
- Core practical methods may be used in other contexts, e.g. indicator solutions, iodine test for starch.

Practical Skills and Understanding of the Scientific Method

- Students should be familiar with typical school laboratory equipment at the appropriate levels.
- Students should understand how to plan experiments that will generate valid data.
- Students should understand how to analyse and evaluate the quality of data at an appropriate level.

International GCSE Biology Core Practicals

2.9 Investigate food samples for the presence of glucose, starch, protein and fat

2.12 Investigate how enzyme activity can be affected by changes in temperature

2.14B Investigate how enzyme activity can be affected by changes in pH

2.17 Investigate diffusion and osmosis using living and non-living systems

2.23 Investigate photosynthesis, showing the evolution of oxygen from a water plant, the production of starch and the requirements of light, carbon dioxide and chlorophyll

2.33B Investigate the energy content in a food sample

2.39 Investigate the evolution of carbon dioxide and heat from respiring seeds or other suitable living organisms

2.45B Investigate the effect of light on net gas exchange from a leaf, using hydrogencarbonate indicator

2.50 practical: investigate breathing in humans, including the release of carbon dioxide and the effect of exercise

2.58B Investigate the role of environmental factors in determining the rate of transpiration from a leafy shoot in humans, including the release of carbon dioxide and the effect of exercise

3.5 Investigate the conditions needed for seed germination

4.2 Investigate the population size of an organism in two different areas using quadrats

4.4B Investigate the distribution of organisms in their habitats and measure biodiversity using quadrat

5.6 Investigate the role of anaerobic respiration by yeast in different conditions

International GCSE Human Biology Core Practicals

2.4	investigate the qualitative and quantitative content of vitamin C in food
2.5	investigate the energy content of food
2.8	investigate the effect of temperature and pH on enzyme activity
2.10	investigate the action of immobilised enzymes including the preparation of alginate beads
5.7	investigate the number and position of sensory receptors, such as touch and temperature receptors in the skin
5.15	investigate the range of frequency audible to the human ear
7.2	investigate the difference between inspired and expired air for carbon dioxide concentration
7.2	investigate the difference between inspired and expired air for carbon dioxide concentration
8.5	investigate the effect of exercise on the rate of breathing and measure lung capacity
8.11	investigate the effect of exercise on the pulse rate
10.10	investigate diffusion using a partially-permeable membrane such as Visking tubing

International GCSE Single Science Core Practicals

2.9	investigate food samples for the presence of glucose, starch, protein and fat
2.12	investigate how enzyme activity can be affected by changes in temperature
2.23	investigate photosynthesis, showing the evolution of oxygen from a water plant, the production of starch and the requirements of light, carbon dioxide and chlorophyll
4.2	investigate the population size of an organism in two different areas using quadrats
5.6	investigate the role of anaerobic respiration by yeast in different conditions

International AS and A Level Core Practicals

1. Use a semi-quantitative method with Benedict's reagent to estimate the concentrations of reducing sugars and with iodine solution to estimate the concentrations of starch, using colour standards.
2. Investigate the vitamin C content of food and drink.
3. Investigate membrane properties including the effect of alcohol and temperature on membrane permeability.
4. Investigate the effect of temperature, pH, enzyme concentration and substrate concentration on the initial rate of enzyme-catalysed reactions.
5. (i) use a light microscope to make observations and labelled drawings of suitable animal cells (ii) use a graticule with a microscope to make measurements and understand the concept of scale
6. Prepare and stain a root tip squash to observe the stages of mitosis.
7. Use a light microscope to: (i) make observations, draw and label plan diagrams of transverse sections of roots, stems and leaves (ii) make observations, draw and label cells of plant tissues (iii) identify sclerenchyma fibres, phloem, sieve tubes and xylem vessels and their location. None
8. Determine the tensile strength of plant fibres.
9. Investigate the antimicrobial properties of plants, including aseptic techniques for the safe handling of bacteria
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.
11. Carry out a study on 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.
12. Investigate the effects of temperature on the development of organism (such as seedling growth rate, brine shrimp hatch rates)
13. Investigate the rate of growth of microorganisms in a liquid culture, taking into account the safe and ethical use of organisms.
14. Investigate the effect of different antibiotics on bacteria
15. Use an artificial hydrogen carrier (redox indicator) to investigate respiration in yeast.
16. Use a simple respirometer to determine the rate of respiration and RQ of a suitable material (such as germinating seeds or small invertebrates).
17. Investigate the effects of exercise on tidal volume, breathing rate, respiratory minute ventilation and oxygen consumption using data from spirometer traces.
18. Investigate the production of amylase in germinating cereal grains.

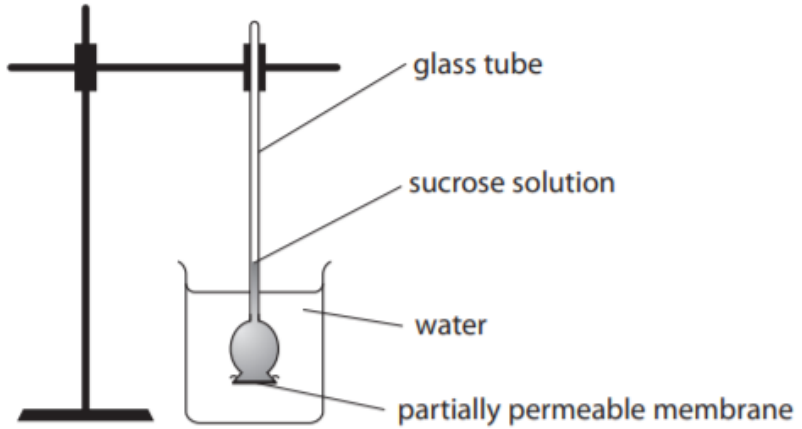
How are Core Practicals Assessed?

This is an example of a core practical from:

2.17 Investigate diffusion and **osmosis** using living and **non-living systems**

It also tests general practical skills in part (b)

4 This apparatus can be used to show osmosis.



(a) Explain what happens to the level of the sucrose solution in the glass tube.

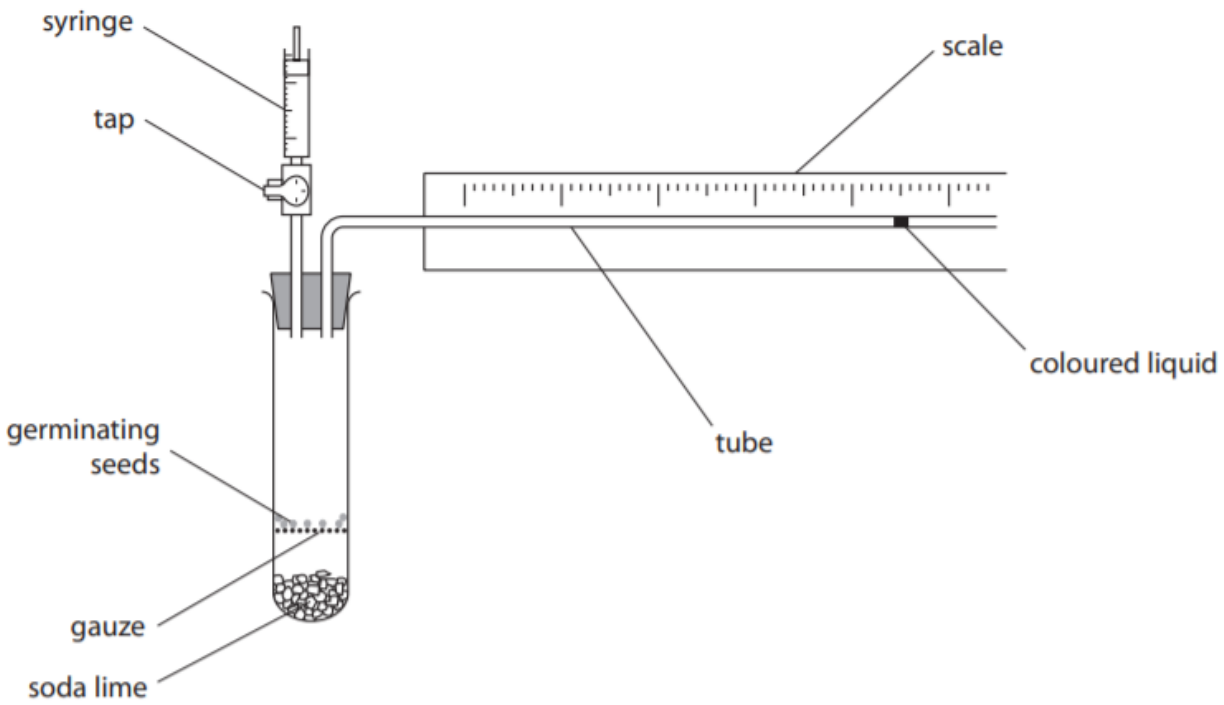
(3)

(b) Describe how this apparatus could be modified to measure the rate of osmosis at different temperatures.

(3)

(b) A student investigates the oxygen absorbed by germinating seeds at different temperatures.

The diagram shows some of the student's apparatus.



(i) Suggest why the student opens the tap after obtaining one set of results.

(2)

(ii) What is the function of the soda lime?

(1)

- ☐ **A** it absorbs carbon dioxide
- ☐ **B** it absorbs oxygen
- ☐ **C** it releases carbon dioxide
- ☐ **D** it releases oxygen

This has aspects of two Core Practicals in an unfamiliar context

2.23 Investigate photosynthesis, showing the evolution of oxygen from a water plant, the production of starch and the requirements of light, carbon dioxide and chlorophyll

2.39 Investigate the evolution of carbon dioxide and heat from respiring seeds or other suitable living organisms

Delegate Exercise 1: How do you use core practicals and what problems have you encountered?

Discuss with other delegates how you use core practicals in your teaching.

- Write down three problems that you have encountered with core practicals.
- How do you incorporate Core Practicals into your scheme of work?
- Do you use Core Practicals to teach general practical skills such as data analysis, planning and the consideration of uncertainty?

Using Core Practicals to Develop General Practical Skills

Core practicals are a useful opportunity to practise general practical skills.

They can enable students to develop planning skills, analytical skills and evaluation of practical techniques.

Some skills can be assessed on the papers in a different context, for example:

- the use of bicarbonate indicator
- the use of colorimeters
- using soda lime to remove carbon dioxide
- using a method to ensure random placements of quadrats

Experimental Skills and Assessment Objective 3 (AO3)

- General practical skills and understanding of the ‘scientific method’ are also assessed on the exam papers.
- This area is covered by **Assessment Objective 3 (AO3).**

At GCSE: ‘Experimental skills, analysis and evaluation of data and methods in biology.’

At AS and A Level: ‘Experimental skills in science, including analysis and evaluation of data and methods.’

Experimental Skills

What experimental skills do students need to understand at:

- International GCSE Level
- International AS and A Level?

International GCSE Experimental Skills

Experimental skills

The best way to develop experimental skills is to embed practical investigations in teaching or theory. The development of knowledge and experimental skills can then happen together, leading to secure acquisition of both knowledge and skills.

Our practical investigations are embedded within *2: Biology content* as specification points in italics. The skills developed through these and other practicals will be assessed through written examinations.

In the assessment of experimental skills, students may be tested on their ability to:

- solve problems set in a practical context
- apply scientific knowledge and understanding in questions with a practical context
- devise and plan investigations, using scientific knowledge and understanding when selecting appropriate techniques
- demonstrate or describe appropriate experimental and investigative methods, including safe and skilful practical techniques
- make observations and measurements with appropriate precision, record these methodically and present them in appropriate ways
- identify independent, dependent and control variables
- use scientific knowledge and understanding to analyse and interpret data to draw conclusions from experimental activities that are consistent with the evidence
- communicate the findings from experimental activities, using appropriate technical language, relevant calculations and graphs
- assess the reliability of an experimental activity
- evaluate data and methods taking into account factors that affect accuracy and validity.

IAS compulsory unit

Externally assessed

Unit description

Introduction

Students are expected to develop experimental skills, and a knowledge and understanding of experimental techniques, by carrying out the core practicals and other recommended practical investigations and experiments while they study Units 1 and 2. This will require them to work safely, produce valid results and present data in the most appropriate format.

This unit will assess students' ability to apply their knowledge and understanding of experimental design, procedures and techniques developed throughout Units 1 and 2.

Practical skills identified for assessment

- Solve problems set in practical contexts.
- Apply scientific knowledge to practical contexts.
- Comment on experimental design and evaluate scientific methods.
- Present data in appropriate ways.
- Evaluate results and draw conclusions with reference to measurement uncertainties and errors.
- Identify variables, including those that must be controlled
- Plot and interpret graphs.
- Process and analyse data using appropriate mathematical skills (see *Appendix 6: Mathematical skills and exemplifications*).
- Know and understand how to use a wide range of apparatus, materials and techniques safely, appropriate to the knowledge and understanding in this specification.
- Plan an investigation to test a hypothesis.

Practical skills to be developed through teaching and learning

- Apply investigative approaches and methods to practical work.
- Use a range of practical equipment and materials safely and correctly.
- Follow written instructions.
- Make and record observations.
- Present information and data in a scientific way.
- Use appropriate software and tools to collect and process data.
- Use online and offline research skills, including websites, textbooks and other printed scientific sources of information.
- Cite sources of information correctly.
- Use a wide range of experimental and practical instruments, equipment and techniques appropriate to the knowledge and understanding included in this specification.

Planning

Questions on Unit 3 may require students to plan and evaluate an investigation, based on the practical activities included in Units 1 and 2.

Students will be assessed on their ability to:

Plan an experiment

- identify the apparatus required
- identify the dependent and independent variables, standardised or controlled variables
- describe how to measure relevant variables using the most appropriate instrument and correct measuring techniques
- identify and state how to control all other relevant variables to make it a fair test
- discuss whether repeat readings are appropriate
- identify health and safety issues and discuss how they may be dealt with
- discuss how the data collected will be used
- identify possible sources of uncertainty and/or systematic error and explain how they may be reduced or eliminated
- comment on the implications of biology (for example benefits/risks) and on its context (for example social/environmental/historical).

Implementation and measurements

Students will be assessed on their ability to:

Implementation and measurements	• comment on the number of readings taken • comment on the range of measurements taken • comment on significant figures • check a reading that is inconsistent with other readings, for example a point that is not on the line of a graph • comment on how the experiment may be improved, possibly by using additional apparatus (for example to reduce errors).

Processing results

Students may be provided with experimental data in a tabulated or graphical form.

Students will be assessed on their ability to:

Processing results	• perform calculations, using the correct number of significant figures • plot results on a graph using an appropriate scale • use the correct units throughout • comment on the relationship obtained from the graph • determine the relationship between two variables or determine a constant with the aid of a graph, for example by determining the gradient using a large triangle • suggest realistic modifications to reduce errors • suggest realistic modifications to improve the experiment • discuss uncertainties, qualitatively and quantitatively.

IA2 compulsory unit

Externally assessed

Unit description

Introduction

Students are expected to develop a wide knowledge and understanding of experimental procedures and techniques throughout the whole of their International Advanced Level course. They are expected to carry out the core practicals and other recommended practical investigations and experiments while they study Units 4 and 5.

Students are expected to become aware of how these techniques and procedures might be used to investigate interesting biological questions.

This unit will assess students' ability to apply their knowledge and understanding of experimental procedures and techniques, and their ability to plan whole investigations, analyse data and to evaluate their results and experimental methodology.

Practical skills identified for assessment

- Solve problems set in practical contexts.
- Apply scientific knowledge to practical contexts.
- Comment on experimental design and evaluate scientific methods.
- Present data in appropriate ways.
- Evaluate results and draw conclusions with reference to measurement uncertainties and errors.
- Identify variables, including those that must be controlled.
- Plot and interpret graphs.
- Process and analyse data using appropriate mathematical skills (see *Appendix 6: Mathematical skills and exemplifications*).
- Know and understand how to use a wide range of apparatus, materials and techniques safely, appropriate to the knowledge and understanding in this specification.
- Plan an investigation to test a hypothesis.

Practical skills to be developed through teaching and learning

- Apply investigative approaches and methods to practical work.
- Use a range of practical equipment and materials safely and correctly.
- Follow written instructions.
- Make and record observations.
- Present information and data in a scientific way.
- Use appropriate software and tools to collect and process data.
- Use online and offline research skills, including websites, textbooks and other printed scientific sources of information.
- Cite sources of information correctly.
- Use a wide range of experimental and practical instruments, equipment and techniques appropriate to the knowledge and understanding in this specification.

Planning

Questions on Unit 6 may require students to plan an investigation to test a hypothesis, based on the practical activities included in Units 1, 2, 4 and 5.

Students will be assessed on their ability to:

Plan an experiment

- identify the most appropriate apparatus, giving details. Apparatus may include the range and resolution of instruments and/or relevant dimensions of apparatus (for example the area of a quadrat used for an ecological investigation)
- formulate a null hypothesis
- identify the dependent and independent variables, standardised or controlled variables
- discuss calibration of instruments, for example whether a meter reads zero before measurements are made
- describe how to measure relevant variables using the most appropriate instrument(s) and techniques
- identify and state how to control all other relevant variables to make it a fair test
- discuss whether repeat readings are appropriate
- identify health and safety issues and discuss how they may be dealt with
- identify any ethical issues involved with the use of living organisms
- discuss how the data collected will be used

Students will be assessed on their ability to:

Implementation and measurements	• comment on how the experiment could have been improved, possibly by using additional apparatus (for example to reduce errors) • comment on the number of readings taken • comment on the range of measurements taken • comment on significant figures – students may be required to identify and/or round up any incorrect figures in a table of results • identify and/or amend units that are incorrect • identify and check a reading that is inconsistent with other readings, for example a point that is not on the line of a graph.

Analysis

Students may be expected to explain how data collected should be presented and analysed.

Students will be assessed on their ability to:

Analyse data	• explain how data should be tabulated, with appropriate units • perform calculations, using the correct number of significant figures • plot results on a graph using an appropriate scale and units – the graph could be logarithmic in nature • use the correct units throughout • comment on the trend/pattern obtained • determine the relationship between two variables or determine a constant with the aid of the graph, for example by determining the gradient using a large triangle • suggest realistic modifications to reduce errors

Summary of Practical Assessment Areas

There are three broad areas of practical assessent:

- Planning experimental work
- Implementation of experimental work
- Analysis and evaluation of data and methods.

Planning Skills

Students are expected to be able to plan investigations that will produce valid data, at both International GCSE level and International AS & A Level.

The basic ideas behind a valid plan are similar at all levels.

- Identification of independent, dependent and control variables.
- Use of repeat readings.

International AS and A Level planning requires more detail, explanation and precision than GCSE.

International GCSE Planning

At International GCSE Level, use CORMS to get students to plan practicals……

CORMS and Planning Investigations

- Each year there is a question asking candidates to design an experiment on the International GCSE Biology and Double Award Science. Human biology also assesses experimental planning.

- This is typically worth 6 marks and will expect candidates to plan an unfamiliar experiment.

- Tests candidates' understanding of controls and choice of method to generate valid data.

- Continuous prose….. BUT…..

  plan it first using CORMS THEN write out the practical plan.

CORMS and Designing Investigations

Change (control)	=	+ and - **or** a range of values (1) Independent variable
Organism (biotic)	=	same species / size / age / sex / eq (1) Controlled variable
Repeat (reliable)	=	more than one reading / eq (1)
Measure	=	mass / length - something that can be measured, not 'amount' (1) over a **stated** time period e.g. one hour (1) Dependent variable
Same (abiotic)	=	two controlled abiotic variables e.g. temp. / LI / water etc (2) Controlled variable

CORMS Clarification

C – change:

- be clear what is being set up

O – organism:

- stated factors, not just “same animal”
- Avoid vague terms like “size”. Refer to mass / length etc.

R – repeats:

- for reliability so must be at each value not at additional values
- idea of making it possible to take means

M - measure:

- usually two marks
- usually for a change / before and after
- measurable quantities (length, mass not just growth / size / amount).
- usually a rate so specify a sensible time (appropriate);;

S - same:

- usually two variables that are relevant and would affect the results;;

Delegate Exercise 2

Write down the mark points for this International GCSE question. Come up with 7 mark points in the style of C O R M1 M2 S1 S2

13 Describe an investigation to find out if adding vitamin D to the diet of young children will help to prevent rickets (a deformation of the legs).

Your answer should include experimental details and be written in full sentences.

(6)

.....

Mark Scheme

C: with & without vitamin D / range of vitamin D / different volume of milk (1)

O: same age / same ethnicity / same gender / same health (1)

R: more than one child per treatment / repeat investigation (1)

M1: measure straightness of legs / height / count number with rickets / curvature (1)

M2: time period must be minimum of one month (1)

S1 & S2: same area / same town / same country / same exposure to sunlight / same time outside / same time of year / same diet (2)

Delegate Exercise 3 – Marking sample answers

Use the mark scheme to mark the student answers.

A. I will take 10 children all of the same age (5 years old) and all boys. Five of them will have a normal diet and the other five will have the same diet but additional vitamin D tablets. The children will have their legs X-rayed at the start and then after 1 year they will have them X-rayed again to see how many of them have developed rickets. Because exposure to sunlight causes vitamin D production, all the children will have the same amount of time outdoors.

Total: 6 marks (C, O, R, M1, M2, S1, S2)

B. I will take a girl and measure the length of her legs. I will then give her vitamin D supplements for a year and then measure the length and curve of her legs at the end. I will make sure that everything else is kept the same.

Total: 2 marks (M1, M2)

C. I will take two girls of the same age and give one vitamin D and the other no vitamin D in their food. I will measure the length and strength of their leg bones at the end of a year and see if there is a difference in their lengths. I will then repeat this using different amounts of vitamin D. Everything else will be kept the same.

Total: 4 marks (C, O, M1, M2)

Planning at International AS and A Level – Delegate Exercise 4

What extra detail is needed to plan investigations at AS and A Level compared to GCSE?

‘Devise a method to determine the effect of sucrose concentration on the rate of growth of pollen tubes.’

What would a candidate need to write to produce a valid method at:

- International GCSE
- AS & A Level?

C: range of sucrose solutions (1)

O: pollen from same species of plant (1)

R: use multiple pollen grains (1)

M1: measure length of pollen tubes (1)

M2: for stated time (1)

S1 & S2: same temperature / other minerals / other nutrients / pH etc (2)

International AS and A Level Planning

At AS and A Level, more detail is required for planning.
This could include:

Independent variable: identify, give a number of values, range of values and possible method for making them, e.g. dilutions.

Dependent variable: identify, give a detailed method for collecting data and any precautions that must be made to ensure accuracy and precision.

Equipment: identify appropriate equipment and at A-Level, explain equipment accuracy e.g. 50 cm^3 measuring cylinder to measure volumes of liquid.

Control variables: identify, give methods for how they are controlled.

Safety and ethics: assess any risks, give precautions, state how any living organisms should be treated ethically.

Errors: List potential errors and uncertainty when using equipment.

Analysis: Explain how data will be used, e.g. graphs plotted, how to calculate rates, means. At A Level, may have to give a null hypothesis and suggest stats tests.

The plan is ‘CORMS++’

C: state 5 different concentrations of sucrose and the range. State how they will be made up – how much water and 1M sucrose stock. Solutions placed into cavity slides with pollen then added. Use of appropriate sized pipettes / syringes to measure volumes.

O: pollen grains from same species of plant.

M1: use of microscope to measure length of pollen tubes. Pollen grains are viewed with microscope at medium power. Eyepiece graticule used to measure length and then calibrated using a stage micrometer.

M2: correct stated time given and rate calculated by dividing mean length by time.

R: at least three measured for each sucrose concentration and the mean lengths determined. Anomalies are ignored and / or repeated.

S1 and S2: e.g. pH controlled by adding buffer solution, temperature controlled by using incubator, humidity chambers to control humidity, minerals added to same concentration.

AND

Safety: care taken with glass slides / minerals may be irritant so use of eye protection etc.

May include: null hypothesis / analysis of data / graphs that would be plotted / justification for method

Delegate Exercise 5 – make mark schemes for these questions

3 Germinating cereal grains, such as barley, produce the enzyme amylase.

The production of amylase is affected by gibberellin, a plant growth regulator.

A student formed the following hypothesis.

The higher the concentration of gibberellin, the greater the production of amylase by germinating cereal grains.

Plan an investigation to test this hypothesis.

(a) State two safety issues you would need to take into account.

(2)

(b) Describe preliminary practical work that you might undertake to ensure your proposed method would provide quantitative results.

(3)

(c) Devise a detailed method, including an explanation of how you would control and monitor important variables.

(10)

Question number	Answer	Mark
3(a)	An answer that includes any two of the following points: • risk of growing {bacteria / fungi} (1) • {growth regulators / plant tissue} may cause allergic reaction (1) • sharp instruments / other sensible risk (1)	(2)

Question number	Answer	Mark
3(b)	A description that includes any three of the following points: • find suitable range of concentration of growth regulator (1) • find suitable method for measuring amylase activity (1) • find the time taken for amylase production (1) • identify {other / named} variable that needs to be taken into account (1)	(3)

Question number	Answer	Additional guidance	Mark
3(c)	An answer that includes ten of the following points: • appropriate measurement of dependent variable (1) • measure the dependent variable several times and calculate a mean (1) • at least five concentrations of growth regulator (1) • description of how growth regulator is applied (1) • description of using the endosperm (1) • reference to aseptic conditions (1) • stated time period for incubation (1) • description of using starch as a substrate (1) • description of using iodine solution (1) • repeats at each concentration and mean calculated (1) • control of one variable relating to the cereal grains (1) • control of one other standardised variable (1)	For example, measuring diameter of clear zone Accept description of aseptic methods	(10)

Delegate Exercise 6: mark these answers.

(a) I would take care with the plant tissue and gibberellic acid as they could be harmful. I would also make sure that I was always cutting away from the body with the scalpel.

(b) I would test a broad range of gibberellin concentrations to give a rough idea of the ideal concentration to use. I would also check the best pH to use by adding different buffer solutions and testing the rate of pollen tube growth.

(c) I would soak seed grains in a range of concentrations of gibberellic acid. I would then make up a series of starch agar plates and put the seeds onto the agar. I would place the plates into an incubator at 37oC for 24 hours. After the 24 hours, I would open the plates and pour on iodine solution. The iodine solution will show where the starch has been digested. I will measure the radius that is not black three times and calculate the mean width – the wider the area, the more active the amylase and this means that more amylase is produced. I will repeat this for all the seeds that have been placed into different concentrations of gibberellic acid.

(a) Starch agar plates could grow microbes – I will make sure that everything is sterilised. I will also ensure that I wear safety glasses as some of the solutions could be harmful.

(b) I will see how easy it is to cut open the seeds to find the endosperm tissue. I would also test how long it takes for the amylase to digest starch in a test tube to see how long we need to leave the experiment for.

(c) I would pour six starch agar plates into Petri dishes. I would then make up five different concentrations of gibberellic acid by taking a 1 % stock and diluting them down with distilled water (I would use a 10 cm^3 syringe) to make solutions with concentrations of: 0.2 %, 0.4 % , 0.6 %, 0.8 % and 1.0 %. I will then place three wheat seeds into each of the concentrations in test tubes and also place three into distilled water as a control. After soaking the seeds for 24 hours, I will place the seeds onto the agar and then place them into an incubator at 37 °C. To test how well they have digested the starch, I will cover the plates with iodine solution. Using a 10 cm ruler, I will measure the diameter of each of the clear zones for each seed.

Implementing Practicals

Difficult to assess on paper!

International GCSE:

- Drawing appropriate results tables.
- Stating appropriate (basic) equipment that could be used.
- Describing what the results of experimental tests such as starch and sugar tests.
- Basic health and safety

International AS and A Level:

- Drawing appropriate results tables.
- Drawing biological diagrams – pencil, no shading, no broken lines etc.
- Selecting equipment that could be used, how it is set up and precautions that should be made, e.g. setting up a potometer or respirometer.
- Suggesting alternative methods that could generate more accurate data or explaining how a method should be modified.
- Calculations to correct number of significant figures (to least accurate apparatus)
- Comment on numbers of repeats, appropriateness of ranges etc.
- At A Level, identify or correct the units
- Health and safety

A Level Implementation questions

(d) Describe how your results should be recorded, presented and analysed in order to draw conclusions from your investigation.

(4)

(e) Suggest three limitations of your proposed method.

(3)

Question number	Answer	Additional guidance	Mark
3(d)	A description that includes the following points: • table with headings (1) • means calculated from repeats (1) • {scatter / line} graph format with labelled axes (1) • use of an appropriate statistical test (1)	For example, (Pearson's) correlation coefficient or Spearman's rank	(4)

Question number	Answer	Mark
3(e)	An answer that includes any three of the following points: • difficult to control {all variables / or a named variable} (1) • another factor may be limiting effect of growth regulator (1) • possible contamination with {bacteria / fungi} (1) • more than one growth regulator may be involved (1)	(3)

3 The enzyme urease catalyses the following reaction:

$$\text{urea} \rightarrow \text{ammonia} + \text{carbon dioxide}$$

The effect of pH on this reaction was investigated using the following method.

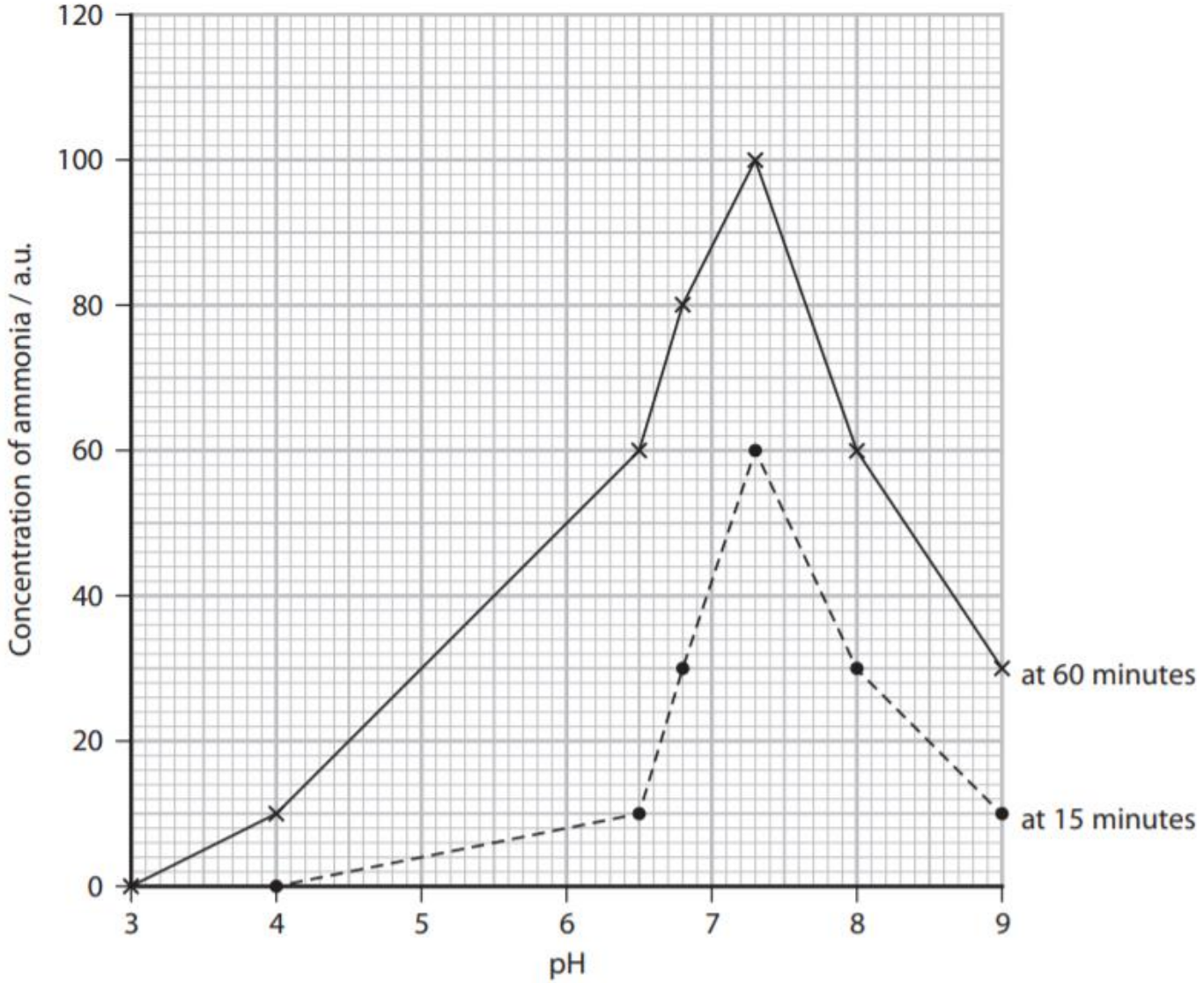
- One test tube containing 5 cm^3 of urease solution was placed in a water bath at 40 °C and left for 10 minutes.
- Another test tube containing 5 cm^3 of urea solution in a buffer at pH 3.0 was placed in the same water bath and left for 10 minutes.
- After 10 minutes, the contents of both tubes were mixed together in one test tube.
- This test tube was replaced in the water bath.
- The concentration of ammonia was measured after 15 minutes and again after 60 minutes.
- The procedure was repeated for pH values of 4.0, 6.5, 6.8, 7.3, 8.0 and 9.0.

(a) (i) Explain why the urease solution and the urea solution were kept in the water bath at 40 °C before and after being mixed.

(4)

Question number	Answer	Additional guidance	Mark
3(a)(i)	An explanation that includes four of the following points: • for equilibration (1) • because mixing the solutions at different temperatures would make the temperature ≠ 40 °C (1) • (40 °C could be) optimum for urease (1) • (so if the mixture) {cooled down / warmed up} rate would change during experiment (1) • ensures only pH is varied (1)	**Accept** when mixing the temperature stays at 40°C / constant	**(4)**

(b) The graph shows the results of this investigation.



(i) Draw a suitable table to include the results for the experiment at 60 minutes.

(4)

<table>
<tr><th>Question number</th><th>Answer</th><th>Additional guidance</th><th>Mark</th></tr>
<tr><td>3(b)(i)</td><td>A table showing the following features:

• suitable table drawn
(1)

• headings of pH and concentration of ammonia
(1)

• with units
(1)

• data correctly entered
(1)</td><td>Example of table drawn

<table><tr><th>pH</th><th>concentration of ammonia / a.u.</th></tr><tr><td>3.0</td><td>0</td></tr><tr><td>4.0</td><td>10</td></tr><tr><td>6.5</td><td>60</td></tr><tr><td>6.8</td><td>80</td></tr><tr><td>7.3</td><td>100</td></tr><tr><td>8.0</td><td>60</td></tr><tr><td>9.0</td><td>30</td></tr></table></td><td>(4)</td></tr>
</table>

Analysis and Evaluation of Data and Methods

International GCSE:

- Processing data: Explain, discuss and evaluate data from experiments. Analysis of quantitative and qualitative data. Graph plotting. Recognising trends. Calculations (rates, means, percentages.)
- Evaluating data strength: Use trend lines, identify and account for outliers / anomalies. Assess reliability (repeats) and validity (controls.)
- Evaluating method: Does the apparatus generate accurate data (close to true values.) Suggesting improvements and justifying them.

International AS and A Level:

- Processing data: Calculations. Appropriate graph plotting – students to determine the correct graph to plot, e.g. bar chart or line of best fit. Explain, discuss and evaluate data to draw conclusions. Analysis of quantitative and qualitative. Data is more complex than GCSE.
- Evaluating data strength: Use trend lines, identify correlations and account for outliers / anomalies. Understand standard deviations. Assess reproducibility / repeatability and validity. At A Level, statistical analysis may be assessed.
- Evaluating methods: Determining error and uncertainty. Suggesting improvements to methods and justify them.

(v) The students concluded that as temperature increases, membrane permeability increases.

Using the information in the table and graph, criticise this conclusion.

(5)

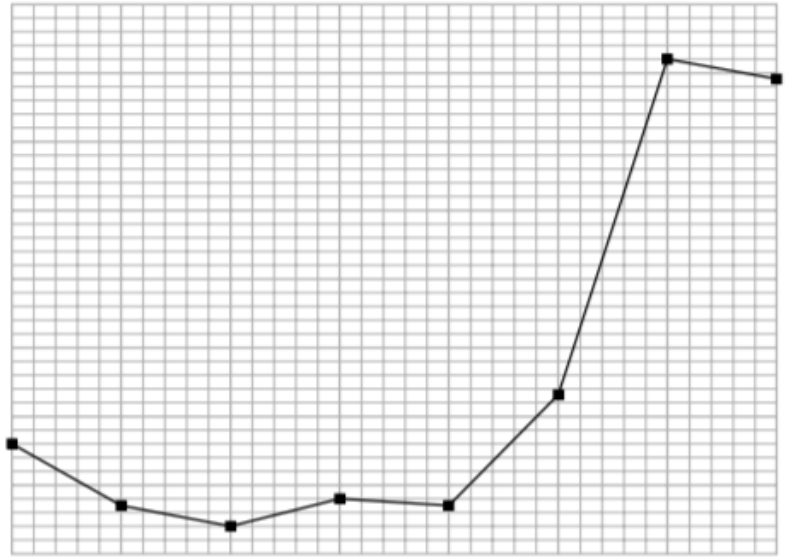
(iii) The table shows the results of this investigation.

Temperature /°C	Intensity of the red colour / a.u.						
	Student 1	Student 2	Student 3	Student 4	Student 5	Mean	Standard deviation
0	0.20	0.15	0.30	0.00	0.13	0.16	0.11
10	0.00	0.14	0.06	0.03	0.12	0.07	0.06
20	0.03	0.08	0.04	0.04	0.02	0.04	0.02
30	0.20	0.04	0.04	0.04	0.06	0.08	0.07
40	0.18	0.04	0.04	0.04	0.07	0.07	0.06
50	0.10	0.26	0.00	0.60	0.18	0.23	0.23
60	0.60	0.89	0.80	0.80	0.55	0.72	0.15
70	0.75	0.50	0.75	0.75	0.70	0.69	0.11

The graph showing the relationship between temperature and the mean intensity of red colour is incomplete.

Complete the graph.

(3)



Question number	Answer	Mark
3(b)(v)	An answer that includes any five of the following points: • (overall) the intensity of the red colour increases as temperature increases (1) • but from 0 °C to 40 °C, the SDs overlap so no significant effect (1) • at 50 °C the mean is higher than that at 40 °C but SDs overlap so there is no case for saying the difference is significant (1) • at 60 °C the mean is higher than that at 50 °C and the SDs do not overlap so this difference can be regarded as significant (1) • at 70 °C the mean degree of redness falls from that at 60 °C but the SDs overlap so temperatures above 60 °C appear to have no further effect (1) • there are no data above 70 °C so cannot say what any further rise in temperature would cause (1)	(5)

(e) The student used a statistical test to investigate the significance of the correlation between the mean heart rate and the caffeine concentration.

To calculate the correlation coefficient, the student produced the following table.

Caffeine concentration % (a)	Mean heart rate (b)	Rank a	Rank b	*d*
0.0	178	1	1	0
0.1	261	2	3	−1
0.5	258	3	2	1
1.0	267	4	4	0
2.0	275	5	5	0
5.0		6	6	0

(i) Calculate the correlation coefficient, r_s, using the formula:

(3)

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

Where:

Σ = the sum of

d = the difference between each pair of ranks

n = the size of the sample (number of pairs of values)

Answer .....

(ii) The table shows some critical values for this statistical test.

Number of pairs of values	Level of significance (p)		
	0.10	0.05	0.01
4	1.000	–	–
5	0.900	1.000	–
6	0.829	0.886	1.000
7	0.714	0.786	0.929
8	0.643	0.738	0.881
9	0.600	0.700	0.833
10	0.564	0.648	0.794

Explain how the student could use the graph and the statistical test to draw conclusions from this investigation.

(5)

(Total for Question 2 = 16 marks)

Question number	Answer	Additional guidance	Mark
2(e)(i)	• calculate the value of d^2 (1) • calculate the value of $6\Sigma d^2$ (1) • calculate the value of r_s (1) Example of calculation: $\Sigma d^2 = 2$ $6\Sigma d^2 = 12$ $r_s = 0.943$	Allow ecf from first or second marking point Correct answer with no working shown gains full marks	(3)

Question number	Answer	Mark
2(e)(ii)	An explanation that includes any five of the following points: • as caffeine concentration increases, heart rate increases (1) • critical value is 0.886 (1) • calculated value (0.943) is higher than critical value (1) • therefore reject the null hypothesis (1) • there is a significant positive correlation between concentration of caffeine and heart rate (1) • low concentrations have a large effect, higher concentrations give a smaller increase (1)	(5)

Key vocabulary – Delegate Exercise 7

There is a lot of practical specific vocabulary!

Give definitions for each of these terms…..

Term	Definition
Accurate	A measure of the closeness of repeated measurements.
Controlled Variable	A measure of the range of values within which the true value lies.
Dependent Variable	A value that is close to the true value
Independent variable	An error that arises due to inconsistency in the experiment. Often causes anomalies.
Precision	An error that is repeated when each measurement is taken, for example if a balance always reads 0.1 g above the true value.
Random error (AS and AL)	An investigation where all variables have been controlled and the results are reliable.
Systematic error (AS and AL)	Factors that would affect the experiment and so need to be maintained constant
Reliable (GCSE)	Results that have been repeated and show similar patterns
Valid	Similar results from different methods and / or equipment.
Uncertainty (AS and AL)	Similar results from the same method.
Reproducible (AS and AL)	The value that would be obtained under ideal conditions.
Repeatable (AS and AL)	The variable that is under investigation and is changed by the experimenter
True value	Variable that is measured as a result of changing another

Term	Definition
Accurate	A value that is close to the true value
Controlled Variable	Factors that would affect the experiment and so need to be maintained constant
Dependent Variable	Variable that is measured as a result of changing another
Independent variable	The variable that is under investigation and is changed by the experimenter
Precision	A measure of the closeness of repeated measurements.
Random error (AS and AL)	An error that arises due to inconsistency in the experiment. Often causes anomalies.
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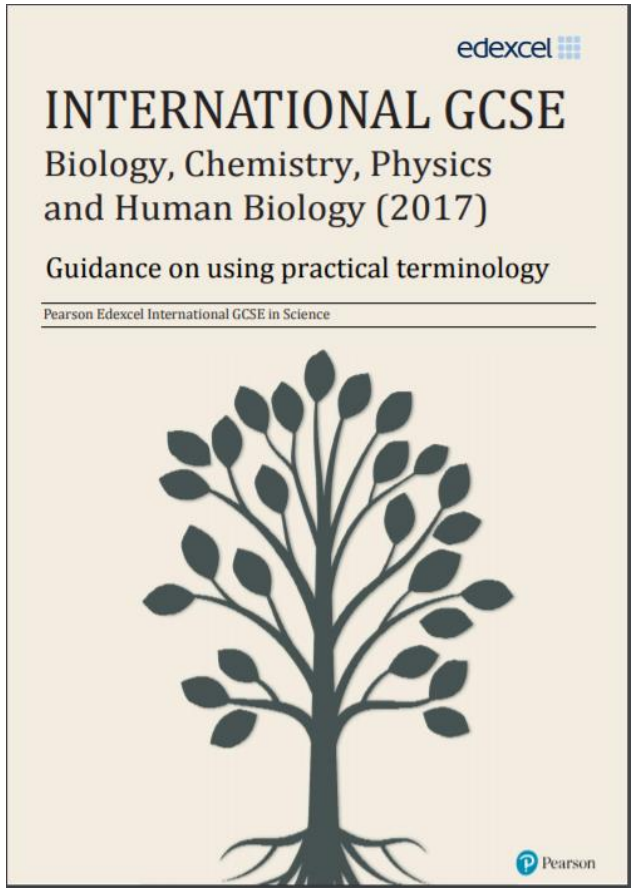
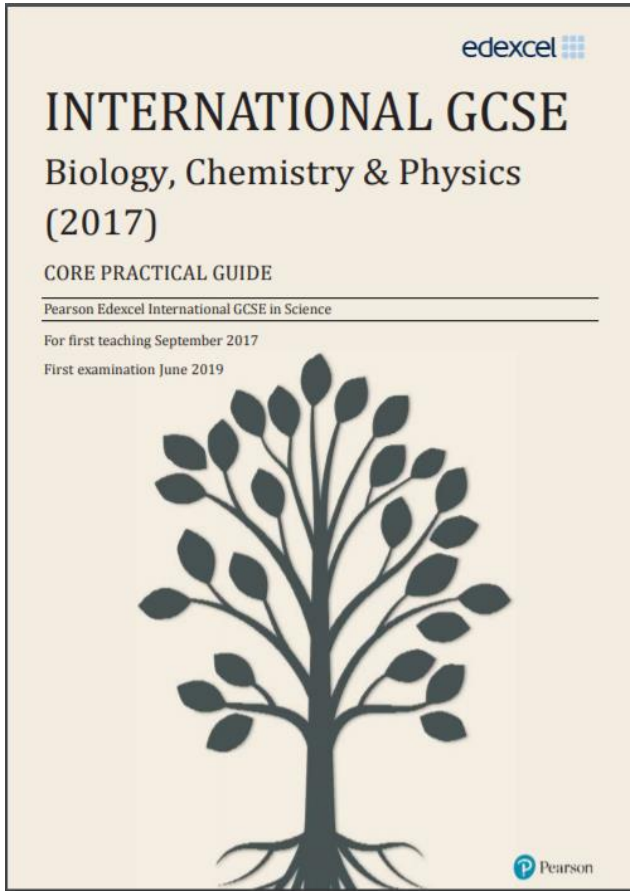
Reliable (GCSE)	Results that have been repeated and show similar patterns
Valid	An investigation where all variables have been controlled and the results are reliable.
Uncertainty (AS and AL)	A measure of the range of values within which the true value lies.
Reproducible (AS and AL)	Similar results from the same method.
Repeatable (AS and AL)	Similar results from different methods and / or equipment.
True value	The value that would be obtained under ideal conditions.

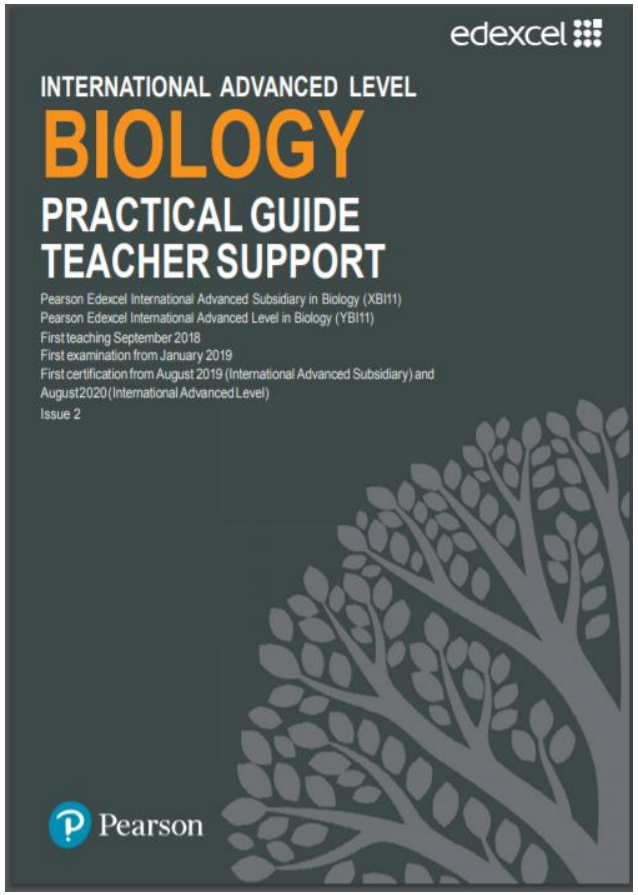
Developing student understanding of experimental work

- Practice practical planning and experimental analysis from a young age
- Introduce CORMS from a young age – scaffold it to help, e.g. you should include in your answer……
- Credit precise language.
- Think up one planning exercise per topic – quick, easy homework task.
- Evaluate class data and always consider accuracy of methods.
- Scaffold 'conclusions' at first, e.g. 'describe the results your graph shows, then explain the trend using the words……..'
- Encourage confident independent exploration by letting pupils 'have a go.'
- Practise, practise, practise……

Support from Pearson







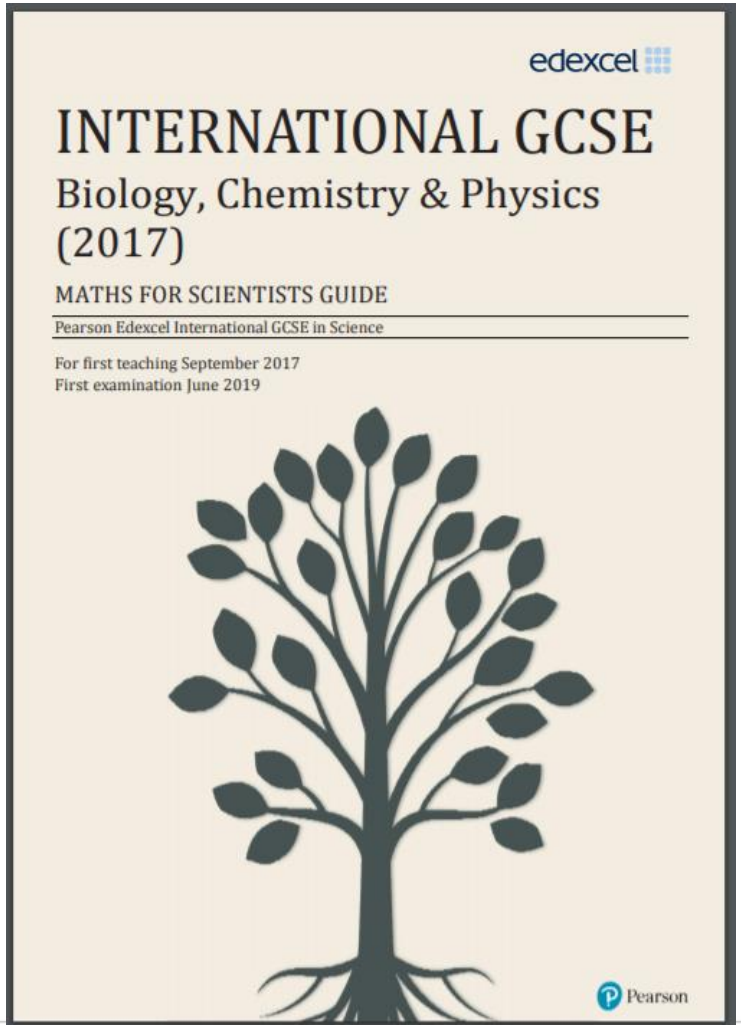
Mathematical Skills

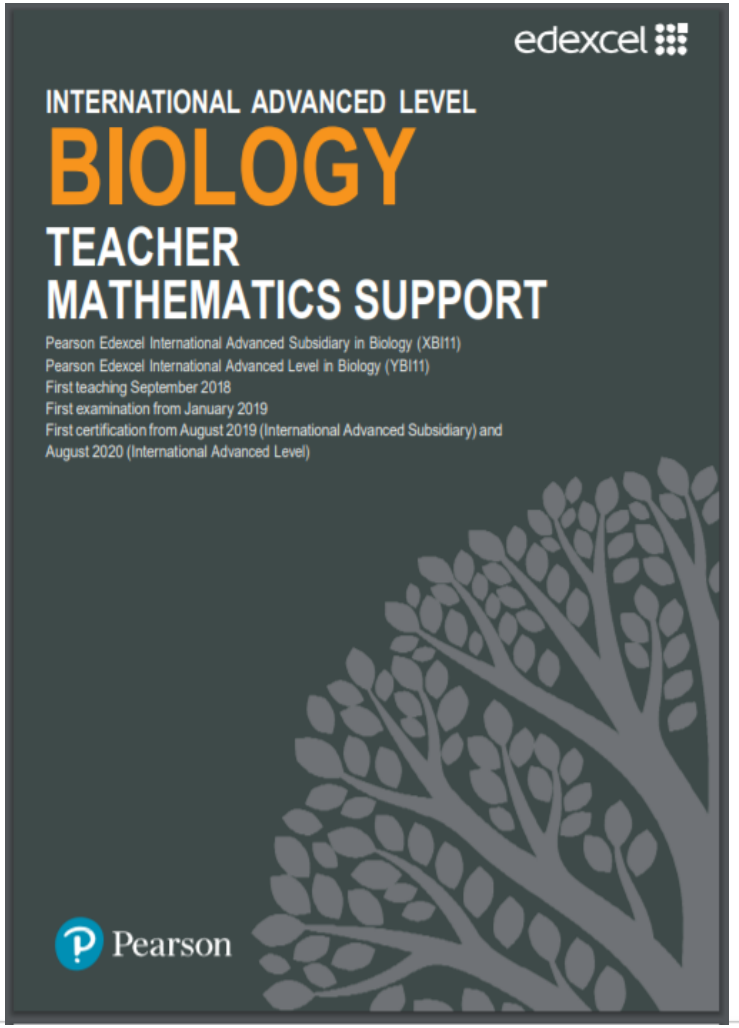
- The development and use of relevant mathematical skills is key to progress in science subjects
- A list of mathematical skills which should be developed appears in the Appendix for each specification
- These skills will be tested in exam papers within the context of the science
- Assessment of mathematical skills will account for 10% of marks in Biology, 20% in Chemistry and 30% in Physics at GCSE and AS / A Level

		B	C	P
1	**Arithmetic and numerical computation**			
A	Recognise and use numbers in decimal form	✓	✓	✓
B	Recognise and use numbers in standard form	✓	✓	✓
C	Use ratios, fractions, percentages, powers and roots	✓	✓	✓
D	Make estimates of the results of simple calculations, without using a calculator	✓		✓
E	Use calculators to handle sin x and $\sin^{-1} x$, where x is expressed in degrees			✓
2	**Handling data**			
A	Use an appropriate number of significant figures	✓	✓	✓
B	Understand and find the arithmetic mean (average)	✓	✓	✓
C	Construct and interpret bar charts	✓	✓	✓
D	Construct and interpret frequency tables, diagrams and histograms	✓		✓
E	Understand the principles of sampling as applied to scientific data	✓		
F	Understand simple probability	✓	✓	✓
G	Understand the terms mode and median	✓		
H	Use a scatter diagram to identify a pattern or trend between two variables	✓	✓	✓
I	Make order of magnitude calculations	✓	✓	✓
3	**Algebra**			
A	Understand and use the symbols $<$, $>$, $\propto$, $\sim$		✓	✓
B	Change the subject of an equation	✓	✓	✓
C	Substitute numerical values into algebraic equations using appropriate units for physical quantities	✓	✓	✓
D	Solve simple algebraic equations	✓	✓	✓
4	**Graphs**			
A	Translate information between graphical and numerical form	✓	✓	✓
B	Understand that $y = mx + c$ represents a linear relationship		✓	✓
C	Plot two variables (discrete and continuous) from experimental or other data	✓	✓	✓
D	Determine the slope and intercept of a linear graph	✓	✓	✓
E	Understand, draw and use the slope of a tangent to a curve as a measure of rate of change		✓	✓
F	Understand the physical significance of area between a curve and the x-axis, and measure it by counting squares as appropriate			✓

		B	C	P
5	**Geometry and trigonometry**			
A	Use angular measures in degrees			✓
B	Visualise and represent 2D and 3D objects, including two dimensional representations of 3D objects			✓
C	Calculate areas of triangles and rectangles, surface areas and volumes of cubes	✓		✓

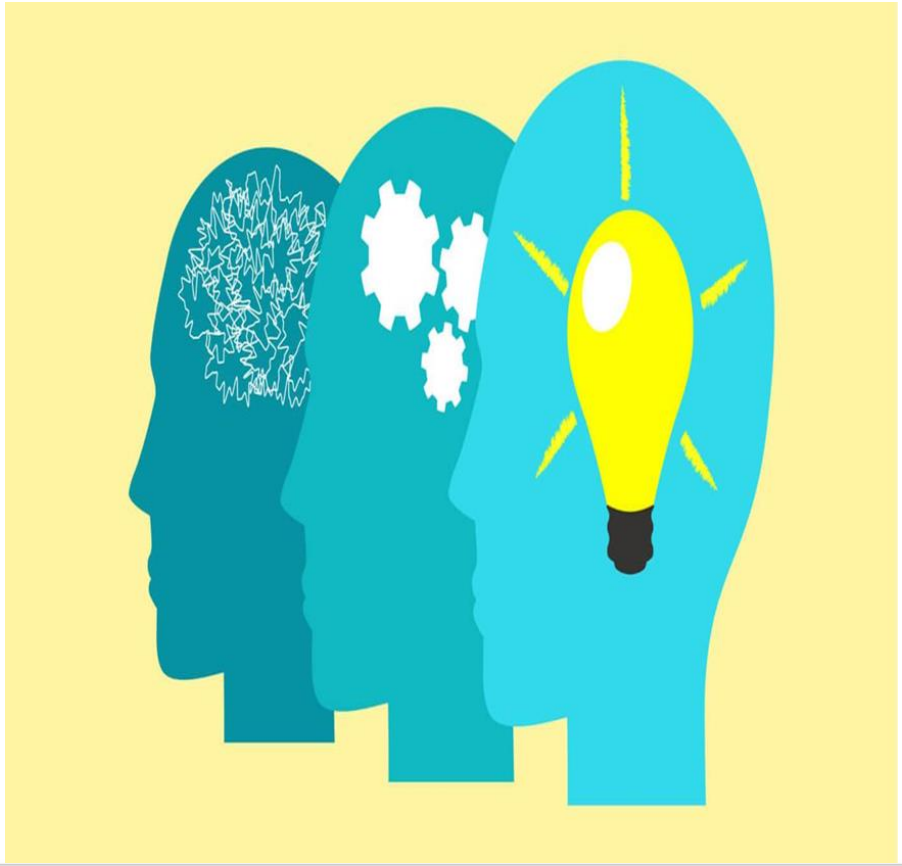
Mathematical Skills





Introduction to Transferable Skills

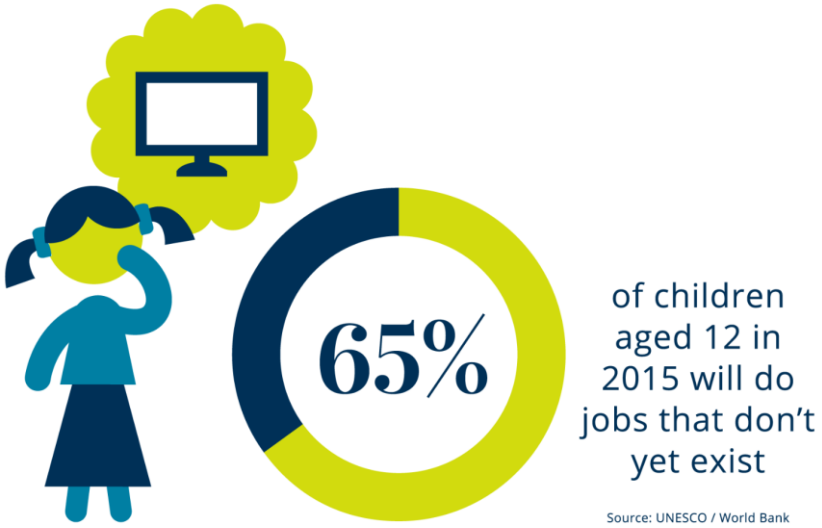
Why Transferable Skills?



Evolving skills

Research consistently highlights the need to:

- Address skills gaps identified by universities and employers
- Prepare learners to adapt to change.



"By far the most important factor employers consider when recruiting school and college leavers is their attitude to work (86%), followed by their aptitude for work (63%) and general academic ability (43%)"

CBI/Pearson Education and Skills Survey 2017

Evolving skills

"the job you have today may require different skills for success tomorrow"

Future of Skills:
Shared implications

THE FUTURE OF SKILLS: EMPLOYMENT IN 2030

EDUCATORS

- Develop new ways of teaching for new types of knowledge and skills
- Adapt faster to needs of the rapidly changing labour market
- Provide more flexible pathways for students

EMPLOYERS

- Re-design jobs to balance benefits of technology productivity and uniquely human skills
- Look beyond university degree as the primary signal of employability

INDIVIDUALS

- Develop “uniquely human” skills
- Commit to lifelong learning

‘Businesses look beyond formal qualifications to wider attitudes and aptitudes when recruiting school and college leavers. But that doesn’t mean qualifications are unimportant. By securing them, young people demonstrate the effort, capability and readiness to learn that businesses want to see.’

CBI/Pearson Education and Skills Survey 2017

What are Transferable Skills?

- The National Research Council (NRC) framework underpins the design of Pearson Edexcel International qualifications and their supporting resources.

- Not all skills are formally assessed.

Cognitive Skills

These are the core skills your brain uses to think, learn and reason – these are used to carry out any task.

They are split into two main categories:

1. Cognitive Processes and Strategies
2. Creativity

Cognitive Skills

"Core skills your brain uses to think, learn and reason – used to carry out any task"

Cognitive Processes and Strategies	Creativity
Critical Thinking	Creativity
Problem Solving	Innovation
Analysis	
Reasoning / Argumentation	

For example, explaining your answer.

Cognitive Skills – Critical Thinking

- Critical thinking refers to the ability to **analyse** information **objectively** and make a **reasoned judgment**.

- A critical thinker is able to:
  - Seek and use relevant sources of information to inform themselves
  - Discriminate between useful and less useful details
  - Use information to draw conclusions, solve problems and make decisions.

- Critical thinking should not be confused with being argumentative or being critical of other people.

Intrapersonal Skills

This is emotional intelligence - the ability to know, understand and manage your **own** emotions and learning.

They are split into three main categories:

1. Intellectual Openness
2. Work Ethic/Conscientiousness
3. Positive Core Self Evaluation

Intrapersonal skills

"This is emotional intelligence, the ability to know, understand and manage your own emotions and learning"

Intellectual Openness	Work Ethic / Conscientiousness	Positive Core Self Evaluation
Adaptability	Initiative	Self-monitoring
Personal and Social Responsibility	Self-Direction	Self-evaluation
Continuous Learning	Responsibility	Self-reinforcement
Intellectual Interest and Curiosity	Perseverance	
Interpretation	Productivity	
Decision Making	Self-regulation (meta-cognition, forethought, reflection)	
Adaptive Learning	Ethics	
Executive Function	Integrity	

Intrapersonal Skills – Initiative

- Initiative is the ability to be **resourceful** and work without always being told what to do. It requires **resilience** and **determination**.

- People who show initiative can **think for themselves** and **take action** when necessary. It means using your head, and having the drive to achieve.

- When you show **initiative**, you:

  - do things without being told
  - find out what you need to know on your own
  - act, instead of reacting.

Interpersonal Skills

The life skills we use everyday to communicate and interact with **other people**, both individually and in groups.

There is one main category:

1. Teamwork and Collaboration

Interpersonal Skills

"The life skills we use everyday to communicate and interact with other people, both individually and in groups"

Teamwork and Collaboration
Communication
Collaboration
Teamwork
Co-operation
Interpersonal Skills
Empathy / Perspective Taking
Negotiation
Leadership
Responsibility
Assertive Communication
Self-Presentation

Interpersonal Skills – Communication

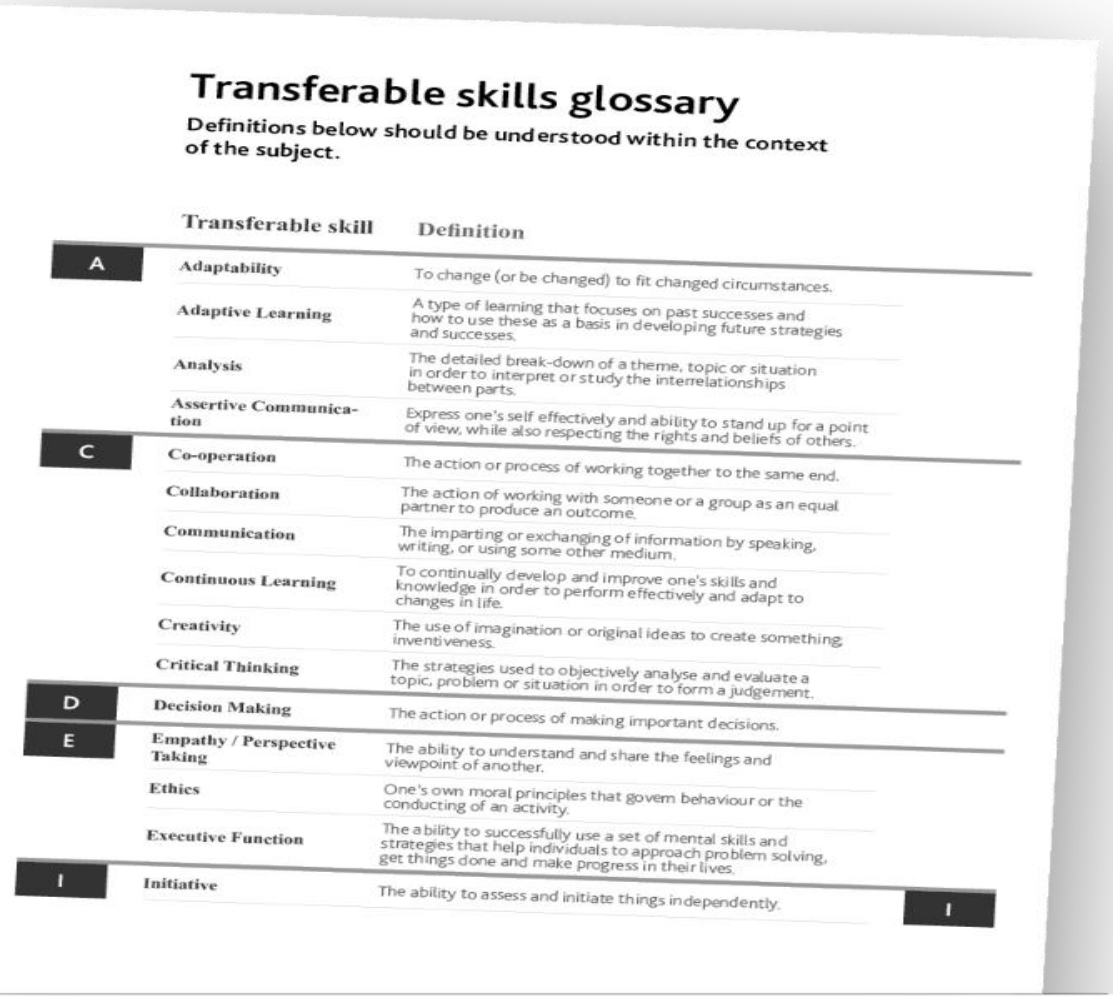
- Interpersonal or people skills are related to the way you **communicate** and interact with people, e.g. listening, questions, understanding body language

- They are also associated with **emotional intelligence**, or being able to understand and manage your own and others' emotions.

- People with good interpersonal skills tend to:
  - work well in a team and other people
  - be able to communicate effectively with others

Transferable skills glossary

A full set of transferable skills definitions can be found in our transferable skills guide



Transferable skills glossary

Definitions below should be understood within the context of the subject.

	Transferable skill	Definition
A	Adaptability	To change (or be changed) to fit changed circumstances.
	Adaptive Learning	A type of learning that focuses on past successes and how to use these as a basis in developing future strategies and successes.
	Analysis	The detailed break-down of a theme, topic or situation in order to interpret or study the interrelationships between parts.
	Assertive Communication	Express one's self effectively and ability to stand up for a point of view, while also respecting the rights and beliefs of others.
C	Co-operation	The action or process of working together to the same end.
	Collaboration	The action of working with someone or a group as an equal partner to produce an outcome.
	Communication	The imparting or exchanging of information by speaking, writing, or using some other medium.
	Continuous Learning	To continually develop and improve one's skills and knowledge in order to perform effectively and adapt to changes in life.
	Creativity	The use of imagination or original ideas to create something; inventiveness.
	Critical Thinking	The strategies used to objectively analyse and evaluate a topic, problem or situation in order to form a judgement.
D	Decision Making	The action or process of making important decisions.
E	Empathy / Perspective Taking	The ability to understand and share the feelings and viewpoint of another.
	Ethics	One's own moral principles that govern behaviour or the conducting of an activity.
	Executive Function	The ability to successfully use a set of mental skills and strategies that help individuals to approach problem solving, get things done and make progress in their lives.
I	Initiative	The ability to assess and initiate things independently.

Session 2: Transferable skills in action

Delegate Exercise 7:What transferable skills could be taught using these examples?

Students plan a practical investigation into the effect of light wavelength on rate of photosynthesis

Sixth for students produce a revision programme for Y11 students about a topic.

Students produce an information leaflet or website to inform the public about the effect of fertiliser use on pollution.

Students design a method for using recycle food and non-food waste from school kitchens.

Now it's your turn – devise four lessons that could deliver transferable skills

?

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https://qualifications.pearson.com/content/dam/p

Intrapersonal skills	
Intellectual Openness	
Adaptability	Select and apply knowledge and understanding of scientific processes, which is not prompted or provided, to problems in biology.
Personal and social responsibility	Appreciate the ethical and social issues in biology.
Continuous Learning	Plan and reflect on own learning, setting goals, meeting and reviewing them regularly.
Intellectual interest and curiosity	Identify a problem under own initiative, plan a solution and carry this out.
Work ethic/conscientiousness	
Initiative	Use knowledge of biology independently, without guided learning, to further own understanding.

Interpersonal skills	
Teamwork and collaboration	
Communication	Communicate a biological process or technique, either verbally or written, to peers and teachers and answer questions.
Collaboration	Carry out a peer review and provide supportive, constructive feedback to another.
Teamwork	Work collaboratively with other students in practical work so that the contribution of every student is valued and effective.
Co-operation	Share own resources and learning techniques with other students.
Interpersonal skills	Use verbal and written communication skills in a dialogue about a topic in biology.
Empathy/perspective taking	Support the position of another in a piece of writing or in an oral presentation.

Cognitive skills	
Cognitive Processes and Strategies	
Critical thinking	Use many pieces of information from different areas of the subject and synthesise the information to make judgments.
Problem solving	Apply unifying patterns and themes in biology and use them in new and changing situations.
Analysis	Analyse and interpret data, experimental methods and results, drawing conclusions which are consistent with evidence from experimental activities.
Reasoning/argumentation	Evaluate evidence related to biology and then bring it together to form a conclusion.
Interpretation	Select, organise and present relevant information clearly and logically using appropriate vocabulary, definitions and conventions.
Decision Making	Evaluate data, experimental methods and results, drawing conclusions that are consistent with evidence from secondary sources and other experimental activities. Suggest possible improvements and

Self-direction	Plan and carry out investigations independently.
Responsibility	Take responsibility for any errors or omissions in own work and create a plan to improve.
Perseverance	Seek new ways to continue and improve own learning, despite setbacks.
Productivity	Develop a fluency in technical vocabulary so that sophisticated answers are produced in extended answers.
Self-regulation (metacognition, forethought, reflection)	Appreciate own knowledge of biology and understand a learning task. Develop and refine a strategy over time for applications of biology to different contexts, reflect on the success or otherwise of the strategy.
Ethics	Produce output with a specific moral purpose for which one is accountable.
Integrity	Take ownership of own work and willingly respond to questions and challenges.
Positive Core Self Evaluation	
Self-monitoring/self-evaluation/self-reinforcement	Plan and review own work as a matter of routine.

Negotiation	Debate an ethical topic or issue in biology, attempting to reach shared conclusions with others, compromising where appropriate using negotiation skills.
Leadership	
Leadership	Lead others in a group activity to effectively encourage and develop learning.
Responsibility	Take responsibility for the outcome of a team activity, even if one is not solely responsible for the outcome.
Assertive communication	Chair a debate, allowing representations and directing the discussions to a conclusion.
Self-presentation	Utilise a number of different opportunities to exhibit communication skills in variety of ways including written and verbal, including presenting a topic to the class.

	further investigations to extend an investigation.
Adaptive learning	Understand unifying patterns and themes in biology and apply them in new and possibly unfamiliar contexts.
Executive function	Plan investigations using knowledge and understanding of experimental and investigative skills, with due regard for correct and safe laboratory procedures. Evaluate the effectiveness of an investigation in terms of accuracy, repeatability and validity.
Creativity	
Creativity	Apply existing knowledge and understanding of biological processes to situations set in a new and possibly unfamiliar context.
Innovation	Use a novel strategy to apply existing knowledge and understanding of biological concepts in new and unfamiliar situations.

Cognitive skills	Cognitive processes and strategies	• Critical thinking • Problem solving • Analysis • Reasoning • 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 • Interpersonal skills
	Leadership	• Leadership • Responsibility • Assertive communication • Self-presentation

Problem solving in the application of unifying patterns and themes in biology and using them in new and changing situations.

Initiative when using knowledge of biology, independently (without guided learning), to further own understanding.

Communication to convey a biological process or technique (verbally or written) to peers and teachers and answer questions from others.

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.

General Discussion

Please fill in your evaluation forms

We value your feedback!

Thank you for your time

Find out more about us at:
http://qualifications.pearson.com