Biology subject report

2025 cohort

January 2026

Queensland Government | QCAA Queensland Curriculum & Assessment Authority

260033

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Contents

Introduction

The annual subject reports seek to identify strengths and opportunities for improvement of internal and external assessment processes for all Queensland schools. The 2025 subject report is the culmination of the partnership between schools and the QCAA. It addresses school-based assessment design and judgments, and student responses to external assessment for General and General (Extension) subjects. In acknowledging effective practices and areas for refinement, it offers schools timely and evidence-based guidance to further develop student learning and assessment experiences for 2026.

The report also includes information about:

- how schools have applied syllabus objectives in the design and marking of internal assessments
- how syllabus objectives have been applied in the marking of external assessments
- patterns of student achievement
- important considerations to note related to the revised 2025 syllabus (where relevant).

The report promotes continuous improvement by:

- identifying effective practices in the design and marking of valid, accessible and reliable assessments
- recommending where and how to enhance the design and marking of valid, accessible and reliable assessment instruments
- providing examples that demonstrate best practice.

Schools are encouraged to reflect on the effective practices identified for each assessment, consider the recommendations to strengthen assessment design and explore the authentic student work samples provided.

Audience and use

This report should be read by school leaders, subject leaders, and teachers to:

- inform teaching and learning and assessment preparation
- assist in assessment design practice
- assist in making assessment decisions
- help prepare students for internal and external assessment.

The report is publicly available to promote transparency and accountability. Students, parents, community members and other education stakeholders can use it to learn about the assessment practices and outcomes for senior subjects.

Subject highlights

449
schools offered Biology

82.67%
of students completed 4 units

99.53%
of students received a C or higher

Subject data summary

Unit completion

The following data shows students who completed the General subject or alternative sequence (AS).

Note: All data is correct as at January 2026. Where percentages are provided, these are rounded to two decimal places and, therefore, may not add up to 100%.

Number of schools that offered Biology: 449.

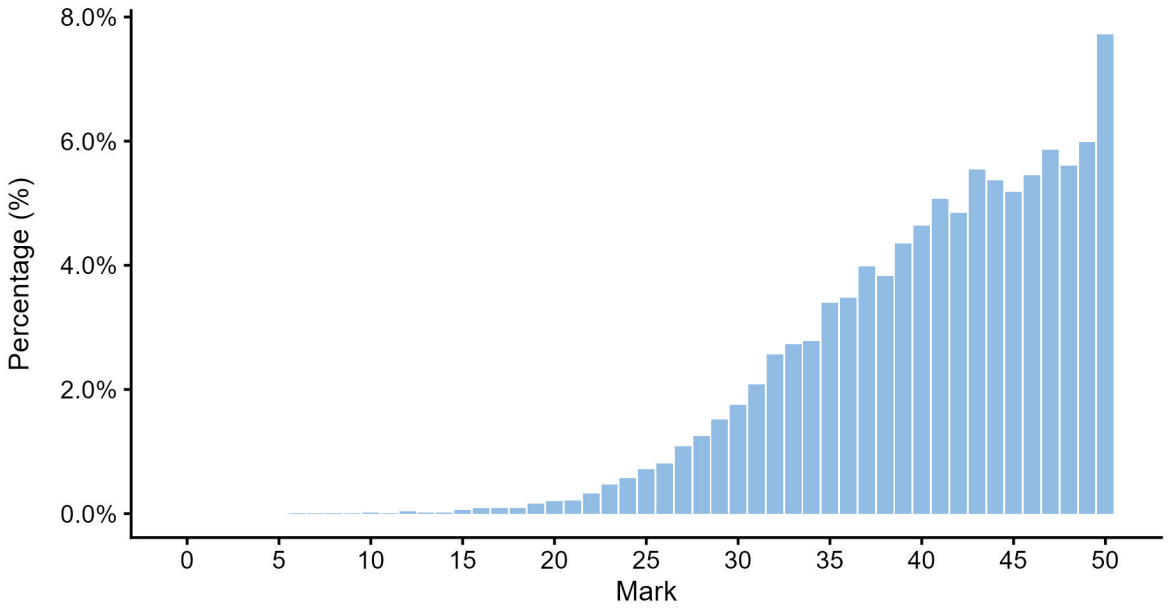
Completion of units	Unit 1	Unit 2	Units 3 and 4
Number of students completed	16,888	15,664	13,961

Units 1 and 2 results

Number of students	Unit 1	Unit 2
Satisfactory	15,727	14,371
Unsatisfactory	1,161	1,293

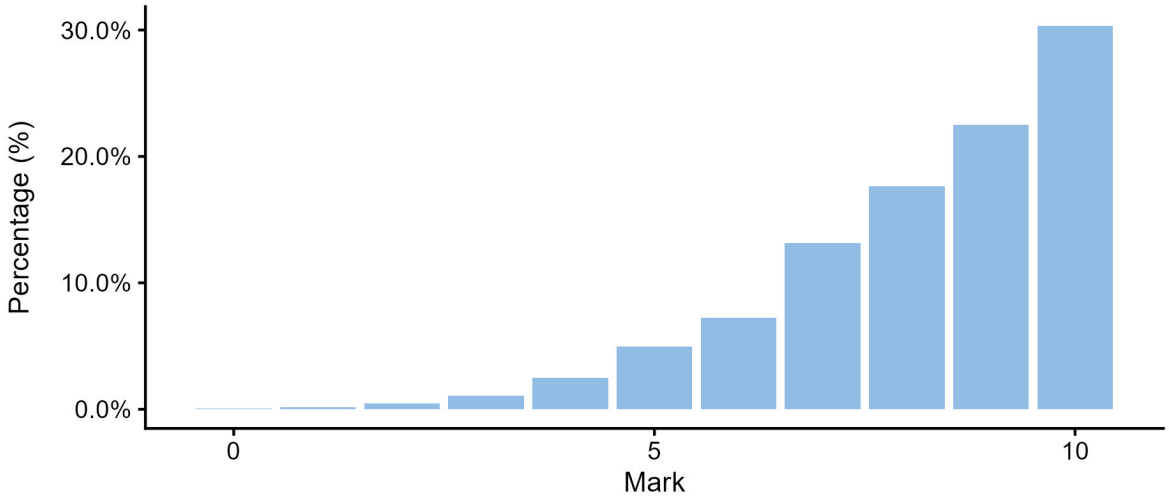
Units 3 and 4 internal assessment (IA) results

Total marks for IA

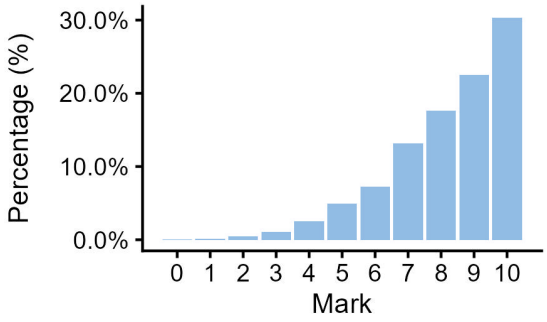


IA1 marks

IA1 total

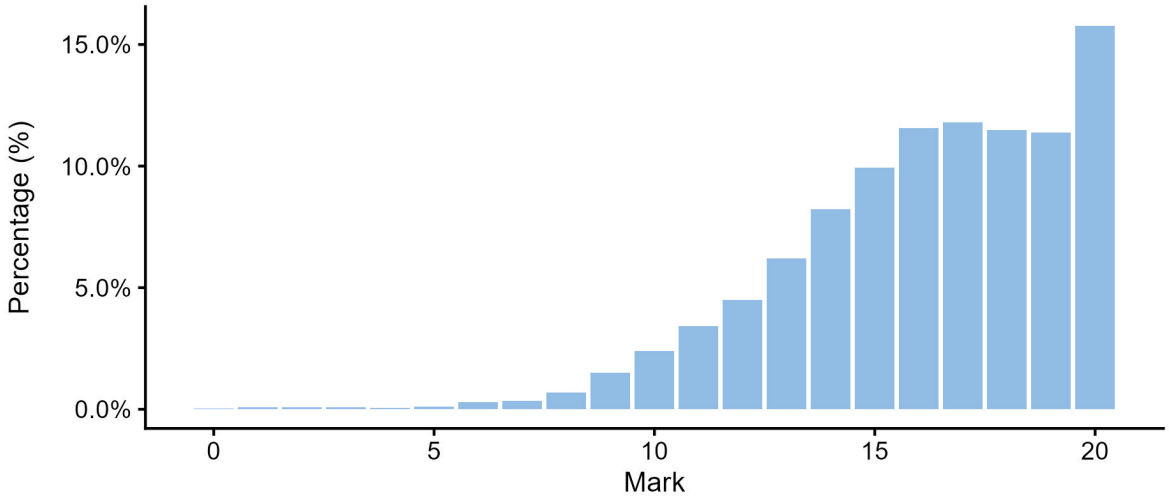


IA1 Criterion: Data test

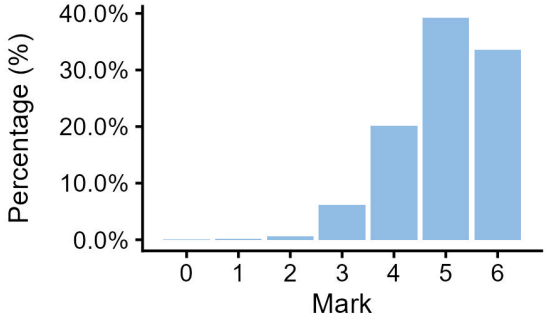


IA2 marks

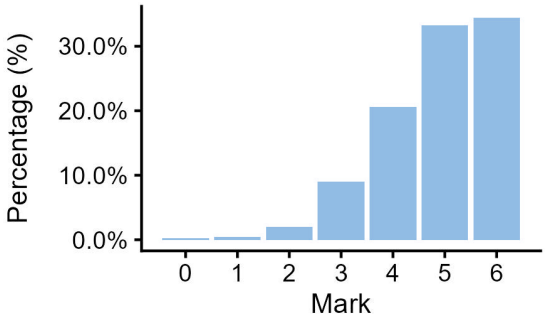
IA2 total



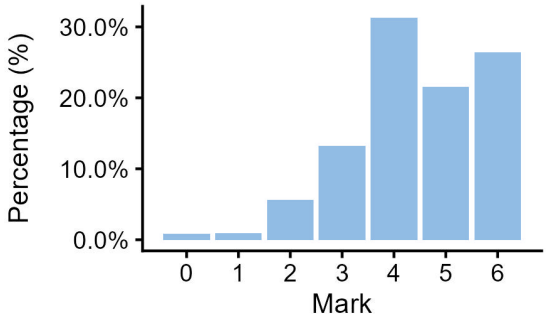
IA2 Criterion: Research and planning



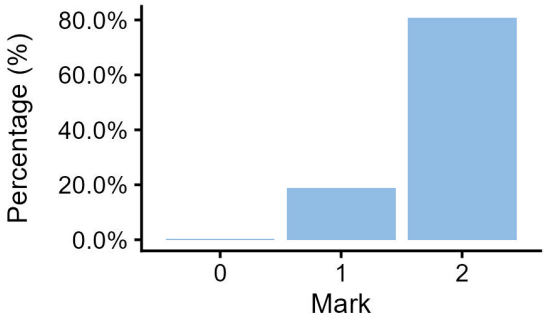
IA2 Criterion: Analysis of evidence



IA2 Criterion: Interpretation and evaluation

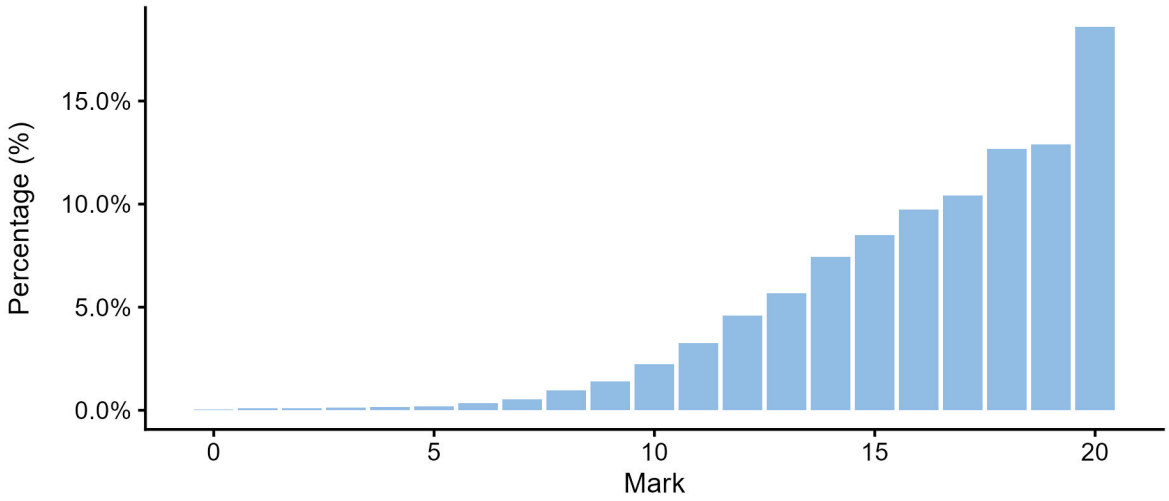


IA2 Criterion: Communication

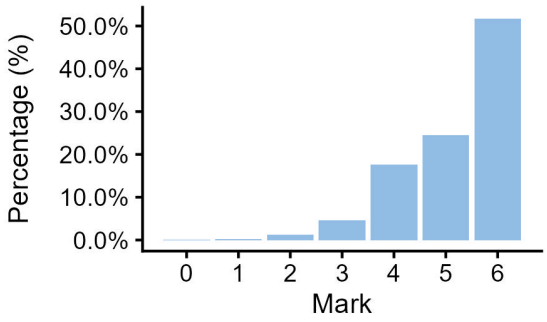


IA3 marks

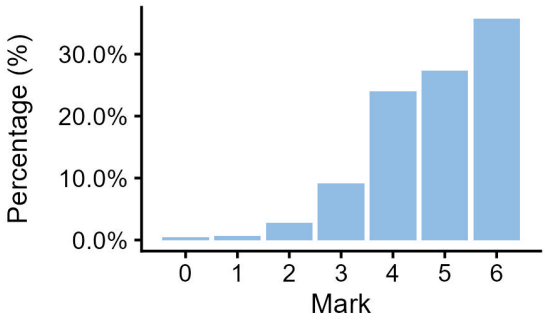
IA3 total



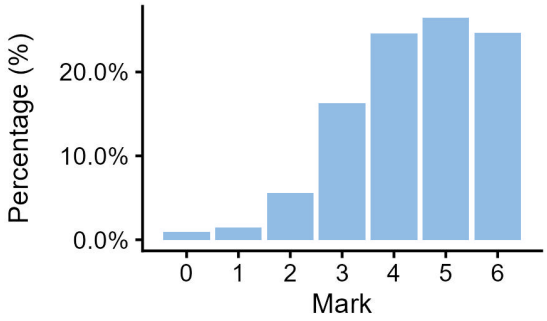
IA3 Criterion: Research and planning



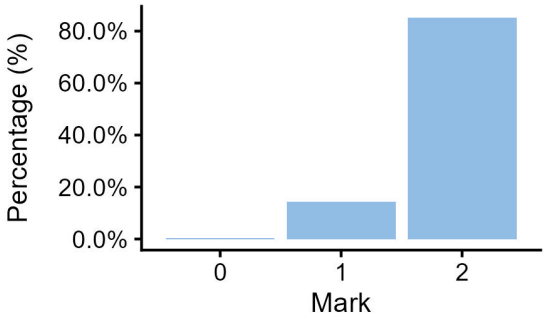
IA3 Criterion: Analysis and interpretation



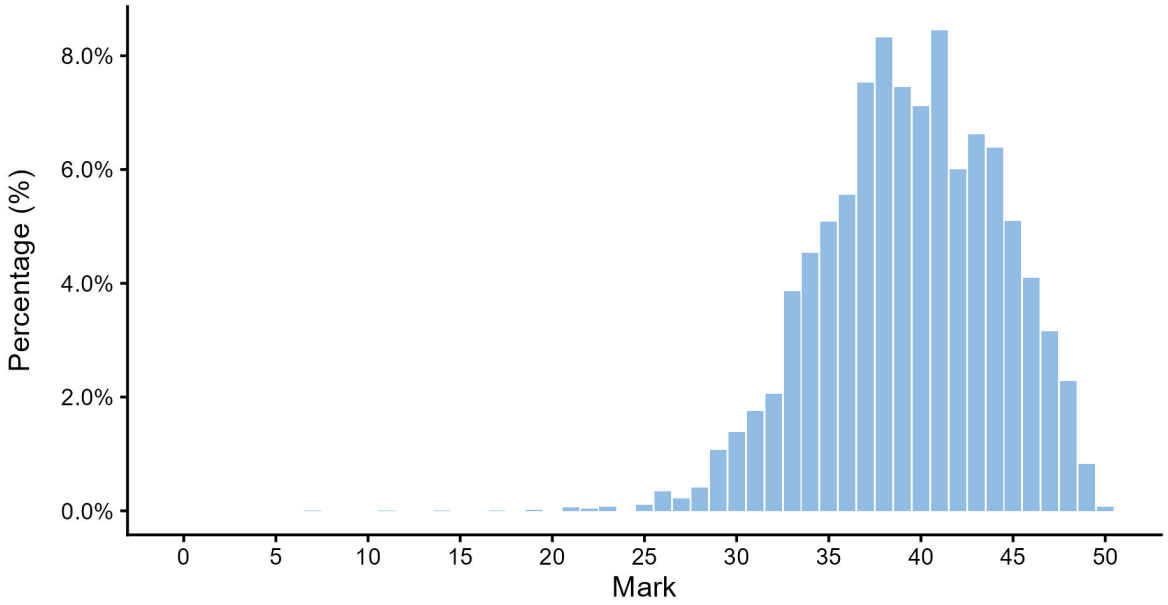
IA3 Criterion: Conclusion and evaluation



IA3 Criterion: Communication

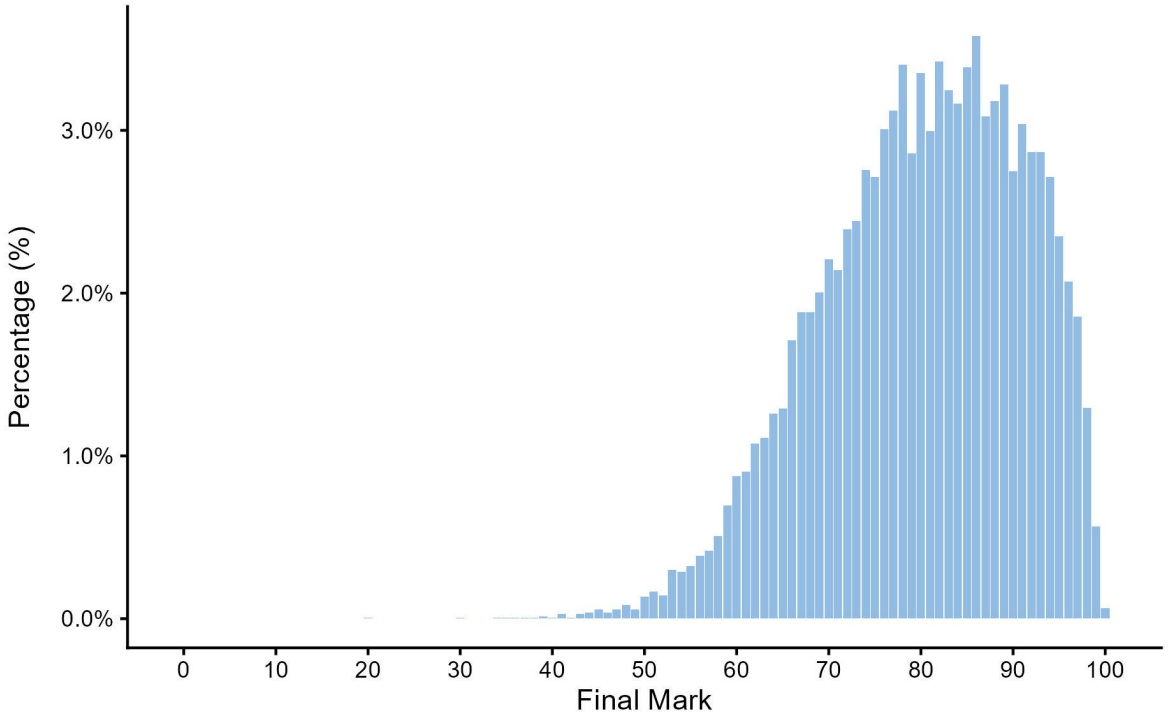


External assessment (EA) marks



Final subject results

Final marks for IA and EA



Grade boundaries

The grade boundaries are determined using a process to compare results on a numeric scale to the reporting standards.

Standard	A	B	C	D	E
Marks achieved	100–87	86–71	70–50	49–20	19–0

Distribution of standards

Number of students who achieved each standard across the state.

Standard	A	B	C	D	E
Number of students	4,465	6,700	2,731	65	0
Percentage of students	31.98	47.99	19.56	0.47	0.00

Internal assessment

This information and advice relate to the assessment design and assessment decisions for each IA in Units 3 and 4. These instruments have undergone quality assurance processes informed by the attributes of quality assessment (validity, accessibility and reliability).

Endorsement

Endorsement is the quality assurance process based on the attributes of validity and accessibility. These attributes are categorised further as priorities for assessment, and each priority can be further broken down into assessment practices.

Data presented in the Assessment design section identifies the reasons why IA instruments were not endorsed at Application 1, by the priority for assessment. An IA may have been identified more than once for a priority for assessment, e.g. it may have demonstrated a misalignment to both the subject matter and the assessment objective/s.

Refer to *QCE and QCIA policy and procedures handbook v7.0*, Section 9.5.

Percentage of instruments endorsed in Application 1

Internal assessment	IA1	IA2	IA3
Number of instruments	450	450	448
Percentage endorsed in Application 1	40	93	85

Confirmation

Confirmation is the quality assurance process based on the attribute of reliability. The QCAA uses provisional criterion marks determined by teachers to identify the samples of student responses that schools are required to submit for confirmation.

Confirmation samples are representative of the school's decisions about the quality of student work in relation to the instrument-specific marking guide (ISMG) and are used to make decisions about the cohort's results.

Refer to *QCE and QCIA policy and procedures handbook v7.0*, Section 9.6.

The following table includes the percentage agreement between the provisional marks and confirmed marks by assessment instrument. The Assessment decisions section for each assessment instrument identifies the agreement trends between provisional and confirmed marks by criterion.

Number of samples reviewed and percentage agreement

IA	Number of schools	Number of samples requested	Number of additional samples requested	Percentage agreement with provisional marks
1	447	3,487	0	100.00
2	446	3,491	22	89.04
3	446	3,470	18	90.60

Internal assessment 1 (IA1)

Data test (10%)

This assessment focuses on the application of a range of cognitions to multiple provided items.

Student responses must be completed individually, under supervised conditions, and in a set timeframe.

Assessment design

Validity

Validity in assessment design considers the extent to which an assessment item accurately measures what it is intended to measure and that the evidence of student learning collected from an assessment can be legitimately used for the purpose specified in the syllabus.

Reasons for non-endorsement by priority of assessment

Validity priority	Number of times priority was identified in decisions
Alignment	212
Authentication	0
Authenticity	3
Item construction	25
Scope and scale	93

Effective practices

Validity priorities were effectively demonstrated in assessment instruments that:

- provided two to four datasets
  - based on practicals, activities or case studies the students had experienced in class
  - of suitable scope and scale to allow appropriately challenging items covering different objectives, e.g. different representations of data with suitable indicators of uncertainty and scope to identify trends, patterns and/or relationships.
- included a series of short response questions that
  - assessed a single objective
  - required students to engage with the datasets, e.g. items requiring students to identify limitations were based on evidence in the data, not the methodology
  - showed clear alignment between the cognitive verb, expected response and mark allocations, e.g. for a 2-mark *infer* question, 1 mark was allocated for drawing a conclusion and 1 mark for providing appropriate reasoning.

Practices to strengthen

It is recommended that assessment instruments:

- align the cognitive verb in the question to the nature of the student response, e.g. questions categorised as Assessment objective 2 (Apply understanding) using the cognitive verb *identify*

require students to identify unknown scientific quantities of features, rather than draw conclusions based on analysis of datasets

- allow students to demonstrate appropriate scale of knowledge and skills by
  - assessing a range of cognitions across the instrument, e.g. for Assessment objective 3 (Analyse evidence) avoiding repetition of the same cognitive verb
  - limiting repetition of skills where multiple instances may occur in a dataset, e.g. develop datasets so that questions only require the calculation of one Simpson's diversity index (SDI) value, identification of a single zone or classification of one site
- include all relevant data in the dataset so that no new data is introduced in the question.

Accessibility

Accessibility in assessment design ensures that no student or group of students is disadvantaged in their capacity to access an assessment.

Reasons for non-endorsement by priority of assessment

Accessibility priority	Number of times priority was identified in decisions
Bias avoidance	21
Language	74
Layout	23
Transparency	61

Effective practices

Accessibility priorities were effectively demonstrated in assessment instruments that:

- contained succinct questions that clearly cued the expected responses through appropriate use of cognitive verbs, suitable response space and appropriate mark allocations
- modelled the correct use of spelling, grammar, sentence structure and scientific conventions, e.g. italicising species names
- had appropriate formatting, spacing and page breaks.

Practices to strengthen

It is recommended that assessment instruments:

- use the correct grammatical syntax for cognitive verbs. For instance, when using the verb *distinguish*, questions should ask students to 'distinguish between' items, values or trends.

Additional advice

When developing an assessment instrument for this IA, it is essential to consider the following key differences between the 2019 and 2025 syllabuses:

- Perusal time has changed to 5 minutes.
- The question specifications table has been revised (syllabus, p. 39). Instruments should be written in line with the revised specifications so each question aligns to the relevant objective, e.g. the cognitive verb *compare* now aligns more closely to Assessment objective 3 as it relates to the similarities and differences.

- Cladistics and phylogeny have been moved into Unit 4, Topic 2. Items assessing this subject matter may no longer align to the specifications for the IA1 data test.
- *Science inquiry* subject matter has been updated to include more practicals and investigations. This may allow for a greater range of datasets with suitable indicators of uncertainty and scope to identify trends, patterns and/or relationships. Schools should consider the *Science inquiry* subject matter when developing datasets and items.

Assessment decisions

Reliability

Reliability refers to the extent to which the results of assessments are consistent, replicable and free from error.

Agreement trends between provisional and confirmed marks

Criterion number	Criterion name	Percentage agreement with provisional	Percentage less than provisional	Percentage greater than provisional	Percentage both less and greater than provisional
1	Data test	100.00	0.00	0.00	0.00

Effective practices

Reliable judgments were made using the ISMG for this IA when:

- the marking scheme clearly showed what each mark was awarded for, including where follow-through (FT) marks were awarded
- student responses were annotated to show how marks were awarded in alignment with the marking scheme, e.g. by including a tick and/or mark for each aspect of the response matched to the marking scheme and writing ‘FT’ when follow-through marks were awarded
- marking schemes were updated to indicate how valid alternative responses were awarded, e.g. ‘for Simpson’s Diversity Index, accept 0.88 or 0.89’.

Practices to strengthen

To further ensure reliable judgments are made using the ISMG for this IA, it is recommended that:

- follow-through marks are only awarded when the cognition or concept being assessed is impacted by an error in a previous step, but the skill or biological knowledge is still demonstrated
- marks are correctly totalled, percentages are accurately determined, and cut-offs from the ISMG are correctly applied to determine provisional marks, e.g. 14/23 = 60.9%, which is greater than 60%, so 7 should be awarded.

Samples

The following excerpts illustrate effective annotation of student responses to show how marks were awarded in alignment with the marking scheme.

Note: The characteristic/s identified may not be the only time the characteristic/s occurred throughout a response.

Excerpt 1

$$\frac{FOV}{\#\ of\ cells} = \frac{0.045}{2} = 0.0225mm$$

$$0.0225 \times 1000 = 22.5\mu m$$

Cell size = 0.0225 mm / 22.5 µm

3

Excerpt 2

The probability that 2 random plants are selected and are from the same species is $(1 - SDI)$. This is because the SDI represents the probability of these 2 additional plants being from different species. The SDI being 0.59. Hence, $1 - 0.59$ is 0.41, therefore, the probability that these 2 additional plants are from the same species is 41% respectively, with a 59% chance of them being from different species.

2

Internal assessment 2 (IA2)

Student experiment (20%)

This assessment requires students to research a question or hypothesis through collection, analysis and synthesis of primary data. A student experiment uses investigative practices to assess a range of cognitions in a particular context. Investigative practices include locating and using information beyond students' own knowledge and the data they have been given.

Research conventions must be adhered to. This assessment occurs over an extended and defined period of time. Students may use class time and their own time to develop a response.

Assessment design

Validity

Validity in assessment design considers the extent to which an assessment item accurately measures what it is intended to measure and that the evidence of student learning collected from an assessment can be legitimately used for the purpose specified in the syllabus.

Reasons for non-endorsement by priority of assessment

Validity priority	Number of times priority was identified in decisions
Alignment	13
Authentication	0
Authenticity	1
Item construction	13
Scope and scale	0

Effective practices

Validity priorities were effectively demonstrated in assessment instruments that:

- provided clear instructions to students, that matched the information in the syllabus
- identified mandatory or suggested practicals consistent with those described in the syllabus
- aligned authentication strategies to the checkpoints.

Practices to strengthen

It is recommended that assessment instruments:

- identify aspects that can be completed in groups, e.g. use asterisks (*) in the task description and a statement explaining the meaning of the asterisk
- include scaffolding that is consistent with Section 8.2.3 of the *QCE and QCIA policy and procedures handbook v7.0*, e.g. if a sample research question is provided, there must be a statement indicating that the sample research question cannot be used.

Accessibility

Accessibility in assessment design ensures that no student or group of students is disadvantaged in their capacity to access an assessment.

Reasons for non-endorsement by priority of assessment

Accessibility priority	Number of times priority was identified in decisions
Bias avoidance	0
Language	7
Layout	0
Transparency	2

Effective practices

Accessibility priorities were effectively demonstrated in assessment instruments that:

- were free from spelling, grammar and formatting issues
- used appropriate formatting and page breaks to separate sections of the task.

Practices to strengthen

There were no significant issues identified for improvement.

Additional advice

When developing an assessment instrument for this IA, it is essential to consider the following key differences between the 2019 and 2025 syllabuses:

- Task specifications have been revised. Schools should ensure the task section of their IA2 student experiment aligns to the task requirements stated on p. 42 of the syllabus.

Assessment decisions

Reliability

Reliability refers to the extent to which the results of assessments are consistent, replicable and free from error.

Agreement trends between provisional and confirmed marks

Criterion number	Criterion name	Percentage agreement with provisional	Percentage less than provisional	Percentage greater than provisional	Percentage both less and greater than provisional
1	Research and planning	94.39	4.71	0.90	0.00
2	Analysis of evidence	94.84	4.26	0.90	0.00
3	Interpretation and evaluation	94.39	4.71	0.90	0.00
4	Communication	99.33	0.45	0.22	0.00

Effective practices

Reliable judgments were made using the ISMG for this IA when:

- for the Analysis of evidence criterion

- *correct* and *relevant* processing of data showed discriminating selection and accurate use of techniques, summary statistics and graphical representations appropriate to the research question, which allowed students to draw meaningful insights from the data, e.g.
  - line graphs with error bars to show trends and uncertainty
  - pie charts or segmented bar charts to show proportions, e.g. species evenness
  - scatterplots with correlation coefficients to identify relationships
  - boxplots or bar graphs with error bars and Student's t-tests to make comparisons
  - charts, maps and/or profile diagrams to show distribution patterns
  - standard deviation and/or standard error to identify uncertainty
- *thorough* identification of trends, patterns and relationships provided meaningful insights from the data that were directly used to answer the research question and/or evaluate the evidence, e.g. identifying *patterns* in uncertainty data, rather than simply restating standard error values
- *thorough* identification of limitations focused on aspects of the data that made the evidence less effective for the purpose of responding to the research question, e.g. by considering factors such as outliers, number of data points, proximity of data points to the line of best fit, spread of data, domain and range, missing data, extraneous variables and confounding factors
- *sufficient* and *relevant* data allowed all aspects of the research question to be answered and enabled thorough analysis of uncertainty
- student experiments using historical evidence as a source of data demonstrated *sufficient* data when primary data (i.e. data collected by the student) was included in the analysis

- for the Communication criterion
  - *fluent* and *concise* use of scientific language and representations was demonstrated through effective use of
    - discipline-specific language (e.g. 'abundance', 'distribution', 'canopy', 'gradient', 'confounding factors', 'strata', 'substrate') and nomenclature (e.g. '*Rhizophora stylosa*' or '*R. stylosa*')
    - symbols (e.g. > , <), units (e.g. 3 µm or 3 x10^{-6} m) and prefixes (e.g. micro)
    - tables, graphs and diagrams
  - *appropriate* use of genre conventions was demonstrated by
    - logical sequencing of ideas, in line with the genre
    - findings presented in appropriate sections, using appropriate tense
    - appropriately labelled and captioned tables, graphs and diagrams, e.g. units included on axis labels; statistical measures represented by error bars identified
    - scale and magnification identified, where appropriate
  - *appropriate* use of referencing conventions was demonstrated through consistent use of an accepted referencing method, e.g. American Psychological Association (APA) or Harvard.

Practices to strengthen

When making judgments for this IA for the 2025 syllabus, it is essential to consider the following key differences between the ISMGs in the 2019 and 2025 syllabuses:

- for the Forming criterion
  - a *considered* rationale shows informed application of unit concepts to establish a clear purpose for the experiment and explains the relevance of the independent and dependent variables
  - *justified* modifications to the methodology explain how each modification will improve the reliability or validity of evidence
  - a *relevant* research question for Unit 3 allows students to investigate biodiversity or ecosystem dynamics, e.g. experiments investigating the effect of abiotic factors on plants must have clear links to Unit 3 concepts such as carrying capacity, population growth and/or species distribution
- for the Finding criterion
  - *considered* management of risks and/or ethical and/or environmental issues show careful and deliberate management of factors specific to the investigation, e.g. adherence to ethical and cultural guidelines, material safety data sheets (MSDS) and appropriate disposal of chemicals
- for the Interpreting and Evaluating criterion
  - a *justified* conclusion addresses all aspects of the research question and is supported by reasoning and evidence
  - *a justified discussion* of
    - reliability uses reasoning (e.g. relevant theory) and evidence (e.g. patterns in uncertainty data) to consider how specific aspects of the experimental design or data collection process affects the extent to which another experimenter will obtain the same results
    - validity links to the purpose of the experiment (as stated in the rationale) and considers how specific aspects of the experimental design affect the extent to which the experiment measured what was intended
  - *logically derived*
    - improvements address aspects of the experiment identified as affecting reliability, e.g. using stratified sampling instead of random sampling to account for zonation
    - extensions address aspects of the experiment identified as affecting validity, e.g. collecting data at different times of the year to investigate seasonal influence on distribution patterns.

Additional advice

It is essential to consider the following key differences between the 2019 and 2025 syllabuses:

- The alignment between criteria and characteristics of evidence within the student response has changed; however, teachers' judgments when determining the appropriate performance level for each characteristic remain the same.

Schools should also:

- refer to the Science inquiry skills (2025 syllabus, pp. 11–13) to ensure students have developed the necessary skills before implementing the student experiment to ensure they can access all aspects of the task specifications.

Samples

The following excerpt has been included to demonstrate a *considered* rationale for an AS Unit 1 research question, which focused on the effect of temperature on catalase activity, by including a clear purpose for the experiment and an explanation of the relevance of the variables.

Note: The characteristic/s identified may not be the only time the characteristic/s occurred throughout a response.

Enzymes are biological catalysts in living organisms, accelerating the rate of biochemical reactions without being altered in the process or shifting the chemical equilibrium of that reaction (Rodgers, 2025). Majority of enzymes are proteins made up of amino acids linked together in polypeptide chains, the sequence of which makes up its primary structure which then determines the three-dimensional structure of the enzyme, including its active site. The active site of an enzyme is the exterior groove where the substrate binds to facilitate the catalysed reaction (Lewis, 2023). Enzymes are substrate specific, meaning one enzyme can usually only catalyse one chemical reaction due to the active site shape being made to suit the substrate: the lock and key model (Meehan, 2023).

Catalase is a key enzyme in the body; responsible for regulating the cellular levels of hydrogen peroxide (H_2O_2). It's mainly located in the liver and red blood cells of animals but is also present in the peroxisomes of plants (Sharma, 2014). H_2O_2 is a reactive oxygen species capable of causing toxicity in the body through corrosive damage, excessive oxygen gas formation, and lipid peroxidation (Watt, Proudfoot, & Vale, 2004). Catalase plays a major role in cells' antioxidant metabolism by breaking down H_2O_2 into water and oxygen as seen in equation 1.

$$2H_2O_2 \rightarrow 2H_2O + O_2$$

Equation 1: Breakdown of H2O2 (Heck, 2015)

The collision theory states, for a chemical reaction to be successful, reactants must collide in a favorable orientation and with sufficient energy (more than the activation energy) for products to form (The Editors of Encyclopaedia Britannica, 2021). Catalysts lower the activation energy of a reaction, increasing the number of successful collisions.

A major factor in the rate of enzyme activity is temperature. If a reaction's environment is of sub-optimal temperature, there's low kinetic energy causing particles to moving slower. As a result, substrates don't collide with enough energy, lowering the rate of reaction (Bartee, 2019). Every enzyme has a unique temperature range where it reaches maximum rate of reaction, called its optimal temperature. When optimal temperature of the extracellular environment is exceeded, enzyme activity decreases until the active site is denatured, at which point the substrate can no longer bind to it (BBC Bitesize, 2019).

Designing an experiment revolving around the level of catalase activity in varying temperatures assists in furthering the understanding of how extracellular environment changes enzymatic activity. As well as its applications beyond the human body, such as in food industries, textile production, and cysteamine determination (Worthington Biochemical Cooperation, n.d.).

It is hypothesised that when the temperature of catalase reaches 40°C, enzymatic activity will be the highest as this temperature resembles body temperature. The highest and lowest temperatures will have the least enzyme activity due to the negative effect of extreme temperatures.

The following excerpts have been included to demonstrate *justified* modifications to methodology for a Unit 3 investigation, which explored the relationship between the distribution and abundance of flat-stemmed wattle and distance from a recreational walking path. The response clearly states how each modification will improve the reliability or validity of evidence and shows clear links to the rationale in Excerpt 1. The response also demonstrates how the method will allow for the collection of *sufficient* data.

Note: The characteristic/s identified may not be the only time the characteristic/s occurred throughout a response.

Excerpt 1

Based on the research, this report will explore ecosystem dynamics and human disturbance gradients by examining plant distribution and abundance relative to recreational walking paths in a dry sclerophyll forest. Specifically, the effect on Flat-Stemmed Wattle *Acacia complanate* (FSW) an Australian native. FSW is imperative to ecosystems, acting as a pioneer species after bushfires and providing food for native wildlife (NSW Flora Online, n.d.).

Excerpt 2

Modifications to Methodology

The experiment was redirected to investigate the correlation between distance from recreational walking paths in a dry sclerophyll forest and the distribution and abundance of FSW. This was explored through stratified sampling in Whites Hill Reserve using belt transect lines.

Refined by:

- The quadrat size was reduced from 10x10m to 4x4m to increase the likelihood of the data representing changes in abundance and distribution of FSW when moving further from the path. This increases validity.
- The number of belt transect lines was increased from one to four. This reduces the impact of outliers, increasing the experimental reliability.
- The data was collected in a dry rather than wet sclerophyll forest as FSW is more predominately found in dry sclerophyll forests (NSW Flora Online, n.d.)
- The transect line was reduced from 70m to 28m as most changes occur within a close range of the walking path. This will increase precision, improving reliability.

Extended/Redirected by:

- The independent variable was changed to distance from a recreational walking path to ensure data collected was valid to the research question, investigate the impact of this common disturbance on ecosystems, and help guide conservation.
- Only FSW was investigated rather than all species to prioritise focus on the one native plant. This will make the data more precise, and valid to the research question.

The following excerpts have been included to demonstrate *considered* management of risks and ethical and environmental issues.

Note: The characteristic/s identified may not be the only time the characteristic/s occurred throughout a response.

Excerpt 1

Research Question

Does distance from the shoreline affect the distribution and abundance of the Striped-Mouth Conniwink (*Bembicium nanum*) and Zebra Top Snail (*Austrocochlea porcata*) across the zones of low-energy rocky shores of NSI?

Excerpt 2

Safety Concerns

Table 1: NSI rocky shore hazards and risk prevention tactics.

Potential Hazard	Risks	Controls	Risk Level
High-energy waves	Being knocked into water, drowning	Always be aware of waves, never turn back to sea	High
Venomous animals	Envenomation (bites/stings)	Wear closed-in footwear, don't put hands in crevices	Low
Algae on rocks	Slipping – grazes, cuts, and broken bones	Wear aqua-shoes, walk carefully, pay attention to surroundings	Medium—High
Sun	Sunburn, heatstroke, dehydration	Wear broad-brimmed hat, long-sleeved shirts and pants, wear sunscreen, stay hydrated	High

Environmental Considerations

To prevent damage to the environment, littering will not occur. Clean shoes will be worn to prevent transporting invasive plant species' seeds to the island. Overturned rocks will be gently replaced, and little noise will be made to prevent scaring off feeding or resting birds.

Cultural Considerations

The traditional custodians of NSI are the Goenpul, Nughi, and Nunukul clans of the Quandamooka people (Redlands Coast Information Centre, 2022). To respect the cultural significance of the land, it and its wildlife will be observed, listened to, and treated with care. Artefacts (e.g., middens) will also be avoided.

The following excerpts have been included to demonstrate *correct and relevant* processing of data for a correlational research question, leading to the *thorough* identification of trends, patterns, relationships, limitations and uncertainty with an *appropriate* use of genre conventions. The scatterplot also provides evidence that *sufficient and relevant* data has been collected through the methodology proposed.

Note: The characteristic/s identified may not be the only time the characteristic/s occurred throughout a response.

Excerpt 1

Research Question

Based on the research, the investigation will follow the question:

Is there a correlation between distance from a recreational walking path in a dry sclerophyll forest (Whites Hill Reserve) and the distribution and abundance of Flat-Stemmed Wattle *Acacia complanate*?

S+R RQ

Excerpt 2

Figure 1. Distance from walking path (m) vs Number of FSW in each quadrat for 4 transects

Figure 1 shows a positive correlation between distance from a recreational walking path and FSW abundance, with abundance increasing as distance increased. This trend is somewhat logarithmic, indicating a decreasing rate of change for the number of FSW. The most FSW within a single quadrat was 12, recorded 12-16m from the path, though this is an outlier. The least was 1, recorded in a 0-4m quadrat. Additionally, FSW variation increases with distance from the path. Data 16-20m and 20-24m from the path ranges from 5-10 and 2-9 FSW wattle respectively, while 0-4m and 4-8m showed 1-3 and 3-5 FSW. The data suggests that greater distance from the path correlates with higher variation and abundance of FSW. This aligns with the ecological theory that recreational walking paths create edge effects, negatively impacting abiotic factors and resulting in poorer conditions for plants (Ballantyne & Pickering, 2015).

However, conclusions drawn from the data have low statistical confidence. The R^2 value is 0.4919, indicating only 49.19% of the variation in abundance of FSW is explained by the changes in distance from the path. Outliers, such as 12 FSW at 12-16m and 2 FSW at 20-24m, create this variation and reduce confidence in trends identified.

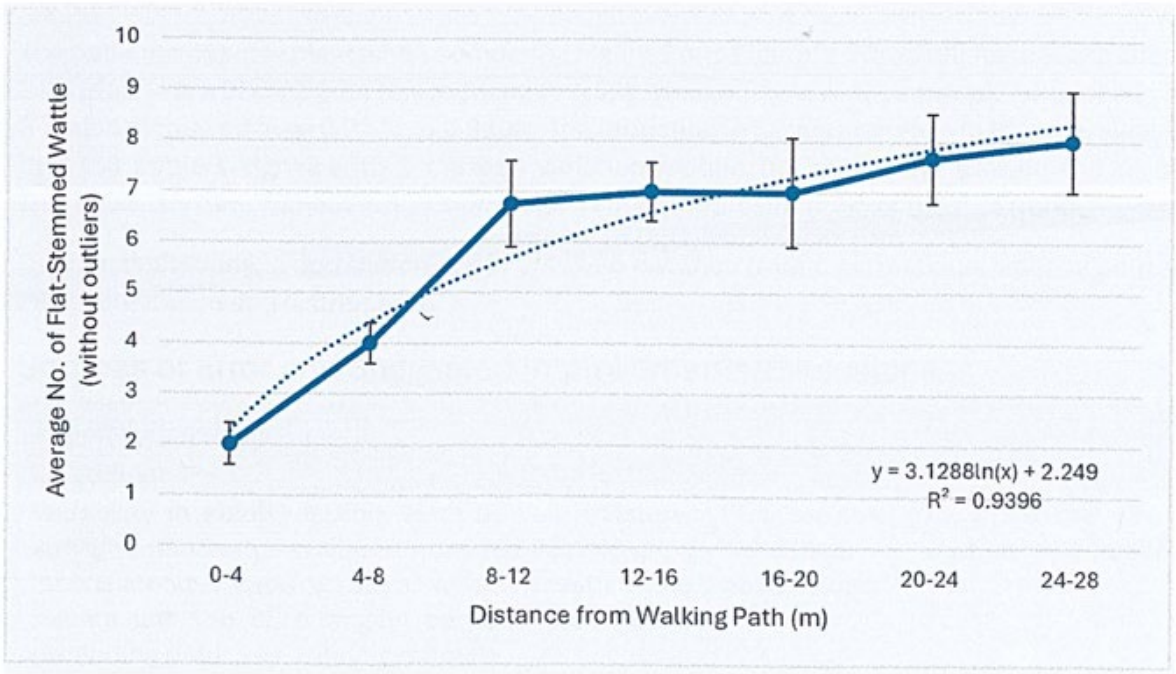


Figure 3. Distance from walking path (m) vs. Average Number of FSW in each quadrat for 4 transects (without outliers)

Figure 3 presents the same data as Figure 2 but without outliers, revealing a clearer logarithmic trend. The graph shows that as distance from the walking path increases, average FSW abundance also increases. However, there is a decreasing rate of change, with the graph plateauing past 8m. For the first three distances, FSW numbers increase steadily (2, 4, 6.75), but beyond this (8-28m) all values remain within a narrow range of 6.75-8. This suggests recreational walking paths significantly reduce FSW abundance within the first 8 metres, beyond which abundance remains consistent. This aligns with ecological theory, as edge effects from recreational walking paths would only occur closest to the path (Ballantyne & Pickering, 2015).

This trend is statistically confident. The data closely follows the trend line, with an R^2 value of 0.9396, which is substantially higher than Figure 2 (0.7973). This indicates minimal variance in the relationship between distance and abundance of FSW. The overlap in error bars for points between 8-28m suggests results for these distances fall within the same range, supporting the conclusion that recreational walking paths only affect FSW abundance within the first 8m. There is no error bar overlap for the points 0-4m and 4-8m with the rest of the data. Thus, strong conclusions can be drawn from Figure 3.

Excerpt 4

Limitations of Evidence

Overall, the evidence shows limited statistical confidence and contains limitations. The small sample size limits experimental reliability. As 4 transect lines were conducted, outliers will skew the data, causing large error bars and reduced confidence in the trend. This is particularly evident in all points past 8m, shown by overlapping error bars (Figure 2). This led to a low R^2 value of 0.4919 (Figure 1) and a weak relationship between distance from the path and FSW abundance.

The outliers impact is clear when comparing Figure 2 and Figure 3. With outliers present, the 20-24m trials had a SD of 3.096, this reduced to 1.528 when outliers were removed. Additionally, the R^2 value increased from 0.7973 to 0.9396. The reduction in SD and increase in R^2 value suggests that the outliers significantly increased variation around the mean and skewed the results. Therefore, the data without outliers provides a clearer representation of the true trend.

Despite limitations, a correlation exists between distance from a recreational walking path and FSW abundance and distribution.

The following excerpt demonstrates *thorough* identification of trends, patterns and relationships by drawing meaningful insights from the data. The response also shows an appropriate use of genre conventions through the logical sequencing of ideas.

Note: The characteristic/s identified may not be the only time the characteristic/s occurred throughout a response.

Interpretation & Analysis

As shown in Table 5, habitat complexity increases from 0.64 at 0m, to 4.07 at 30m, demonstrating that higher complexity scores were recorded further in the mangrove. As research found *(Nagelkerken et al., 2008)*, an increased distance into the mangrove usually correlates to a high HC. Supporting this, figure 2 depicts a clear positive correlation between the mean HC and distance into the mangrove. This represents that interior mangrove zones support more structurally diverse environments compared to the shoreline edge.

The mangrove located on OIRS features more complex terrain deeper into its interior. The interior zones provide a greater variety of microhabitats, likely due to root density, increased canopy and more accumulated organic material. These features contribute to higher levels of complexity in a habitat, by offering shelter and resources for a wider range of species. This is demonstrated by transect points 25m and 30m which were densely covered with mangrove roots and leaves from the canopy. These quadrats had the highest standard errors of 0.3. While these areas are generally more complex, the high standard error suggests uneven foliage distribution, where some quadrats may have been extremely dense while others were more open. This unevenness in root and canopy cover likely made it more difficult to obtain consistent measurements.

The following excerpts have been included to demonstrate a *thorough* identification of trends, patterns and relationships that addresses all aspects of the research question to present meaningful insights from the data.

Note: The characteristic/s identified may not be the only time the characteristic/s occurred throughout a response.

Excerpt 1

How does salt deposition rate, when increasing from 0g/m^2/day to 150g/m^2/day, impact lichen distribution across the intertidal zone at Cape Hillsborough National Park, as assessed with biodiversity metrics of species richness, evenness and abundance?

Excerpt 2

The relationship between salt deposition rate and lichen species richness is quantified by:

$$y = 11.283x^{-0.429}$$

This represents a negative power relationship where, as salt deposition rate increases, species richness decreases. Indicatively, Figure 18 is plateauing. Consequently, increasing the salt deposition rate above 150g/m^2/day will correlate with reduced changes to species richness. An R^2 value of 0.9651 represents a strong correlation between both variables, therefore, indicating that salinity directly impacts lichen distribution.

Evidentially, 6/7 lichen species did not occupy the lower intertidal zone, where salt deposition rate was the greatest (see Figure 16). Hence, minimal ecological tolerance for salinity is demonstrated. Additionally, species evenness decreases as salinity increases. Figure 16 demonstrates that *Ramalina spp.* occupied 100% of the lower intertidal zone. Therefore, species evenness was zero, reducing overall biodiversity. In Figure 9, ecological succession is non-existent at the transect origin, in the lower intertidal zone. Conversely, whilst *Ramalina spp.* was also the dominant species, it only occupied 38% of the supralittoral zone (see Figure 13). Therefore, species evenness was greater, improving overall biodiversity. Indicatively, Figure 9 provides evidence of primary succession at a higher elevation. In Figure 10, this evolved into secondary succession where spinifex grasses, tongue ferns and coastal sheoak are growing.

Furthermore, Figure 20 quantifies the relationship between salt deposition rate and Simpson's Diversity Index (SDI) for lichens as:

$$\text{SDI} = -0.0036x + 0.6186$$

As a negative linear relationship, SDI decreases by 0.36 as salinity increases by 100g/m^2/day. The highest SDI was 0.71 in the supralittoral zone, meaning that there was a 71.0% chance of successively choosing two different lichen species. However, in the lower intertidal zone, SDI was zero, meaning that there was no lichen biodiversity.

The following excerpts have been included to demonstrate a *justified* conclusion linked to the research question, using the *correct and relevant* processing of data for a comparative investigation.

Note: The characteristic/s identified may not be the only time the characteristic/s occurred throughout a response.

Excerpt 1

Considering this information, **how do increasing levels of human disturbance (low, medium, high) at different sites (University of QLD, Brisbane) affect arthropod richness (number of insects and arachnids) in the summer season?**

Excerpt 2

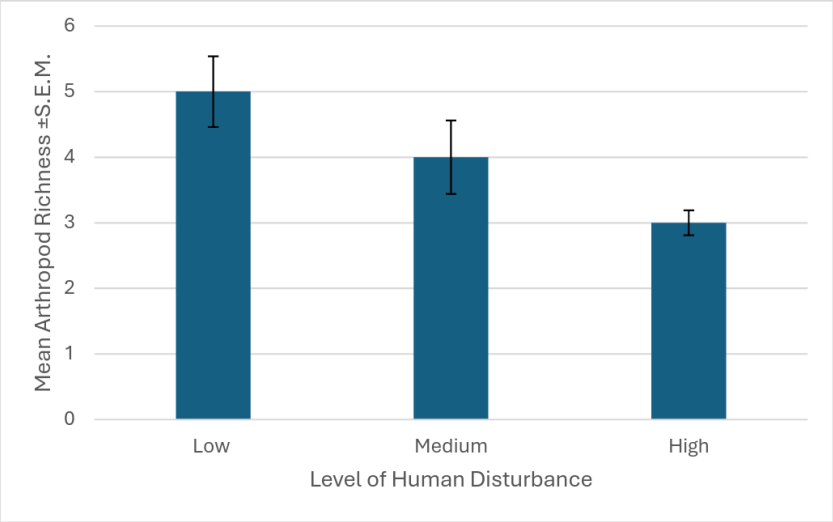


Figure 1: Bar graph with SEM bars for arthropod richness (mean ± S.E.M.) in varied levels of human disturbance (low, medium, high)

Excerpt 3

8.0 CONCLUSION

Ultimately, the answer to the research question is that arthropod richness does generally decrease with increasing levels of human disturbance (low, medium, high) in the summer season. This was shown by the decreasing trend of arthropod richness from low to medium to high levels of disturbance [5(±0.5), 4(±0.6) and 3(±0.2) respectively]. P-values were mostly significant between medium-high and low-high disturbance levels (P = 0.00375, P = 0.0002 respectively). However, there was no significant difference found between low-medium levels (P = 0.0833). Hence, it is unclear whether there are significant differences between level of disturbance and arthropod richness. Uncertainty through relative standard deviation was high (low: 42%, medium: 54%, high: 24%) indicating high variability. While the data does follow scientific literature, possible sources of error such as low number of trials, inconsistent weather conditions, and improper definition of low and medium levels of human disturbance make it unclear whether the data is reliable and valid. To improve this experiment, more samples must be collected in consistent weather conditions and correct definition of human disturbance levels must be made. This experiment could be extended by investigating specific abiotic factors being affected by urbanisation and their impact arthropod richness, as well as increasing the range of human disturbance levels observed. These would increase the data's reliability and validity, enabling it to be extrapolated to the population.

The following excerpt has been included to demonstrate a *justified* discussion of reliability and validity of the experimental process and suggested improvements and extensions that are *logically derived* from the analysis of evidence. The response shows cohesion between different sections of the report, *appropriate* use of scientific representations and *appropriate* use of referencing conventions.

Note: The characteristic/s identified may not be the only time the characteristic/s occurred throughout a response.

Due to the specificity of the research question, external data quantifying the relationship between salt deposition rate and lichen distribution could not be found. However, scientific literature concluded that the net photosynthesis rate in 75% of lichen species decreased with increasing sea-salt concentrations (Nash & Lange, 1988). As the photobiont in lichens are autotrophic, it was inferred that lichen biodiversity decreased with increasing salinity (Gasulla et. al, 2012). Consequently, the negative power and negative linear relationships in Figures 18 and 20 correlate with the true trends. Furthermore, whilst data points significantly deviate from the trendline, they are not systematically lower or higher, indicating moderate accuracy.

Limitations

- Counting methods for percentage abundance were inconsistent. Regardless of the extent of coverage, a quadrat was counted if lichen was present. However, due to poor photographic quality, it was difficult to identify lichen if percentage cover was $< 5\%$. Subsequently, a quadrat was counted if lichen coverage was 10%, leading to skewed results.
- Site selection was biased. 66.67% of sites were in the supralittoral zone, whereas 16.67% were in the lower intertidal zone. This reduced data sufficiency, hence, preventing the development of a complete relationship.
- Locations devoid of lichen species were avoided, and therefore, species richness values were systematically inflated.
- Sample size was limited. Thus, percentage cover and abundance could not be averaged. Consequently, data sufficiency was weak, leading to imprecise calculations.
- Data could not be collected from the subtidal zone, and hence, an important value in the trend was missing, reducing data accuracy.

Reliability

The data had moderate reliability, as indicated by percentage uncertainties of 41.24%, 36.0% and 47.07% (see Figure 22). Error for salt deposition rate was acquired because it was assumed that seawater infiltration depth into lichen tissue was 5.0mm (Schuster et. al, 2002). However, variances in lichen morphology influence water retention, and hence, salinity exposure (Iwan, et. al, 2020). Moreover, salt deposition rate was estimated using data from the United States (Boufadel & Geng, 2015). This introduced significant error as factors influencing salt deposition – water turbidity, evaporation rate, tidal range and freshwater input – differ at Cape Hillsborough (Levronka, 2025). An R^2 value of 0.5879 demonstrates random error in SDI calculations, where it was assumed that $0.01m^2$ of lichen coverage equated to one lichen. This was imprecise as foliose lichens, like *Lichina pygmaea,* cover a greater area than crustose lichens, like *Caloplaca marina.* This lead to disproportionate representation when estimating species abundance by percentage cover. Furthermore, due to poor photographic quality, lichen species were potentially misidentified. For example, at Site F, the lichen's morphology aligned with both *Ramalina spp.* and *Wahlenbergiella mucosa.* Hence, different ecologists may classify the lichen species differently.

Validity

The data had moderate validity, as it depicts the correct relationship where lichen biodiversity decreases as salt deposition rate increases. However, validity was not high as sites with high lichen abundance were consistently analysed, inflating species richness values. This systematic error was offset by poor photographic quality, significantly reducing species richness values. For instance, in Figure 5, brownish-orange spots on the substrate are evident. Whilst this may be *Caloplaca marina* colonies, it could also be iron oxide staining – which is common on igneous rocks (Beltran, 2021). Unable to investigate further, these markings were likely misclassified as abiotic. Systematic undermeasuring of species richness is supported by scientific literature which identified 27 lichen species in an urbanised, coastal environment similar to Cape Hillsborough (Sonina & Androsova, 2021). Moreover, the complete trend is not depicted as data was not collected from the subtidal zone. Therefore, extrapolation – which has inherent error – was required to determine lichen species richness at lower tidal zone heights. This reduced confidence in the trends, affecting data validity.

Improvements

- Use a drone to collect photographic evidence of elevated sites. This would improve photographic quality, and hence, ensure that all lichen species are accurately identified, improving data reliability.
- Calculate the depth of saline water infiltration by homogenising lichen samples in deionised water. By comparing their electrical conductivity to standard NaCl solutions, the depth of water retention

- Use a random number generator to select sites. This would mitigate bias, and hence, ensure that the data accurately represents lichen biodiversity across the intertidal ecosystem.
- Increase the number of sample sites and ensure each tidal zone is equally represented. This would improve data sufficiency, and hence, enable averages for percentage cover and abundance to be calculated. Therefore, the influence of data anomalies would decrease.
- Use an underwater camera to collect data from the subtidal zone. This would mitigate the need to extrapolate Figures 18 and 20, and hence, increase confidence in the depicted relationships.
- Investigate how light intensity impacts lichen biodiversity. This would provide a greater understanding of the abiotic factors that influence lichen distribution.

The following excerpt has been included to demonstrate a *justified* discussion of validity using *fluent and concise* use of scientific language.

Note: The characteristic/s identified may not be the only time the characteristic/s occurred throughout a response.

Affecting validity

Validity is compromised by a sampling methodology that may not have been adequate to fully address the research question. While random sampling aimed to reduced bias, it may not have provided equal representation of all littoral zones. Additionally, as parts of the sublittoral zone were covered by the tide, it was partially inaccessible for data collectors, and therefore, recorded populations may accurately represent only a fraction of the zone. While both species' distribution and abundance could be explained by their distance from the shoreline, it could also be due to other factors, such as salinity, temperatures, or the presence or absence of predators in specific areas. The findings were generally supported by the literature. However, distance (the independent variable) between zones was generalised and it is unclear whether exact boundaries between one zone and the next could even be determined without an extensive knowledge of the indicator species, most of which can move freely beyond the littoral fringes, which leads to further unclarity.

Suggested Improvements and Extensions

The investigation could be improved by conducting a longitudinal study – collecting data from the beach multiple days per week at different times of day for a year, for example, to investigate how seasonal fluctuations in both abiotic (e.g. temperature, salinity) and biotic (e.g. presence of predatory birds) factors affect the species' abundance and distribution. Stratified sampling may also result in a more accurate representation of each littoral zone, giving more precise data.

The investigation could be extended by exploring competition between the two species. Due to their similar diets and inhabiting zones, they may compete for food or space, playing a part in each other's realised niches. Interspecifc competition between Striped-Mouthed Conniwinks and *Austrocochlea constricta* – a species sharing a genus with the Zebra Top Snail – exists due to their similar living conditions and prey, so it is not unreasonable to assume something similar would occur in this case (Ryan & Quinn, 1988). The distribution and abundance of microalgae could also be explored to confirm a relationship between both species and their prey.

Internal assessment 3 (IA3)

Research investigation (20%)

This assessment requires students to evaluate a claim. They will do this by researching, analysing and interpreting secondary evidence from scientific texts to form the basis for a justified conclusion about the claim. A research investigation uses research practices to assess a range of cognitions in a particular context. Research practices include locating and using information beyond students' own knowledge and the data they have been given.

Research conventions must be adhered to. This assessment occurs over an extended and defined period of time. Students may use class time and their own time to develop a response.

Assessment design

Validity

Validity in assessment design considers the extent to which an assessment item accurately measures what it is intended to measure and that the evidence of student learning collected from an assessment can be legitimately used for the purpose specified in the syllabus.

Reasons for non-endorsement by priority of assessment

Validity priority	Number of times priority was identified in decisions
Alignment	40
Authentication	18
Authenticity	2
Item construction	12
Scope and scale	5

Effective practices

Validity priorities were effectively demonstrated in assessment instruments that:

- contained open-ended claims that had only included one context (e.g. either pharmaceutical or agricultural) and were clearly aligned to the topics indicated in the conditions section of the task
- used the task specifications directly from the syllabus without modification.

Practices to strengthen

It is recommended that assessment instruments:

- provide checkpoints indicating that only one almost complete draft is to be submitted, consistent with Section 8.2.5 of the *QCE and QCIA policy and procedures handbook v7.0*
- use claims that are directly linked to the subject matter of the unit and that are not open to potential ethical considerations or non-syllabus content.

Accessibility

Accessibility in assessment design ensures that no student or group of students is disadvantaged in their capacity to access an assessment.

Reasons for non-endorsement by priority of assessment

Accessibility priority	Number of times priority was identified in decisions
Bias avoidance	0
Language	2
Layout	1
Transparency	3

Effective practices

Accessibility priorities were effectively demonstrated in assessment instruments that:

- avoided clerical errors in formatting with appropriate page breaks
- were free from errors in grammar, punctuation and spelling
- provided clear instructions using appropriate language and avoided jargon
- modelled the correct use of scientific conventions for binomial nomenclature (e.g. italicised species names), especially in the scaffolding section.

Practices to strengthen

There were no significant issues identified for improvement.

Additional advice

When developing an assessment instrument for this IA, it is essential to consider the following key differences between the 2019 and 2025 syllabuses:

- The task specifications language has been revised to align with the mid performance-level descriptors in the ISMG, i.e. what students need to do in order to complete this task successfully.
- Examples of scientifically credible sources have been provided in the specifications to direct students to a wider variety of student-accessible sources.
- Group elements have been added to several Forming and Finding activities of the task.
- Subject matter relating to cladistics and phylogeny has been moved into Unit 4, allowing for claims based on these to be used in research investigations.

Assessment decisions

Reliability

Reliability refers to the extent to which the results of assessments are consistent, replicable and free from error.

Agreement trends between provisional and confirmed marks

Criterion number	Criterion name	Percentage agreement with provisional	Percentage less than provisional	Percentage greater than provisional	Percentage both less and greater than provisional
1	Research and planning	96.42	2.46	1.12	0.00
2	Analysis and interpretation	95.53	4.25	0.22	0.00
3	Conclusion and evaluation	94.63	5.37	0.00	0.00
4	Communication	99.55	0.00	0.45	0.00

Effective practices

Reliable judgments were made using the ISMG for this IA when:

- for the Research and planning criterion
  - a *considered* rationale demonstrated informed application of Unit 4 (or AS Unit 2) concepts to clearly show how the research question was developed from the claim
  - a *specific* and *relevant* research question was clearly defined, linked to the claim, required investigation of Unit 4 (or AS Unit 2) concepts and reflected the evidence collected
  - *sufficient* and *relevant* sources allowed students to logically develop the research question and extract enough valid and reliable evidence to answer it
- for the Communication criterion
  - *fluent* and *concise* use of scientific language and representations included accurate use of subject-specific terminology (e.g. ‘gene’ versus ‘allele’), units (e.g. µm or $x10^{-6}$ m) and symbols
    (e.g. < , >) to effectively convey meaning and demonstrate understanding
  - *appropriate* use of referencing conventions was demonstrated by
    - full acknowledgement of sources, ideas and information, e.g. via in-text referencing
    - consistent use of an accepted referencing style, e.g. APA or Harvard
    - a complete bibliography or list of citations
  - *appropriate* genre conventions included appropriate tense; logical sequencing of information, in line with the genre; correct labelling of graphs, tables and diagrams; and inclusion of secondary evidence from multiple sources.

Practices to strengthen

To further ensure reliable judgments are made using the ISMG for this IA, it is recommended that:

- for the Analysing criterion
  - *relevant* evidence is directly related to the research question and presented in a way that allows for *thorough* identification of trends, patterns and/or relationships within and between sources, e.g. by including referenced snips of relevant tables and graphs and/or sequencing the evidence in a logical manner

  - *sufficient* secondary evidence is included to validly address all aspects of the research question and allow for effective analysis and evaluation, e.g. by including multiple sources of evidence to meet the requirements of a research investigation, allow limitations of one source to be addressed by another, and/or establish corroboration between sources.
  - *thorough* and *appropriate* identification of limitations is specific to the research question and identifies how or why each limitation makes the evidence less effective, e.g. by considering which aspect/s of the research question each piece of evidence addresses
- for the Evaluating criterion
  - *insightful discussion* of the quality of evidence considers the strengths and limitations of the evidence in terms of how effectively it addresses the research question and the claim, e.g. by considering the extent to which limitations identified in the analysis (such as bias, currency, relevance, or missing data) affect the overall quality of evidence and the validity of conclusions
  - *justified* conclusions are backed by evidence, specific to the research question and based on scientific arguments developed throughout the response
  - *considered* improvements and extensions focus on ways the research investigation could be refined or extended to obtain more valid or reliable evidence applicable to the claim.

Additional advice

It is essential to consider the following key differences between the 2019 and 2025 syllabuses:

- The alignment between criteria and characteristics of evidence within the student response has changed; however, teachers' judgments when determining the appropriate performance level for each characteristic remain the same.

Schools should also:

- refer to the Science inquiry skills (2025 syllabus pp. 11–13) to ensure students have engaged in the necessary learning before implementing the student experiment to ensure they can access all aspects of the task specifications.

Samples

The following excerpt demonstrates a *considered* rationale for a Unit 4 investigation. The response shows informed application of concepts to clearly show how the research question was developed from the claim.

Note: The characteristic/s identified may not be the only time the characteristic/s occurred throughout a response.

Following the global food crisis of 2008, ensuring the affordability and availability of food and animal feed has become an urgent international prority, resulting in all nations recognising the need to improve agricultural productivity to increase food and feed supply and, consequently, reduce food prices (Gustafson, 2013). One promising avenue towards this goal is genetic modification (GM).

Although some studies raise concerns regarding the potential risks of genetically modified organisms (GMO's)—including allergenicity and environmental impact—the long-term benefits often outweigh these risks (Raman, 2024). Thus, it is necessary to understand the effect of GMOs on crop yields as it is a valuable tool for supporting global food security.

Genetic modification refers to the intentional alteration of an organism's genome using biotechnology to introduce genetic material from another species (Office of the Gene Technology Regulator, 2021). This includes techniques such as transgenesis, gene silencing, and CRISPR-Cas9 gene editing (National Library of Medicine, 2004). For the purposes of this investigation, and to investigate the claim, the term 'genetic modification' will be limited to the transgenesis of Bt yellow corn (GMO). Yellow corn is a globally significant crop, widely used in food, animal feed, and industrial applications, and serves as a dietry staple in regions such as Africa, Latin America, and South Asia (Kaul et al., 2019). Thus, investigating Bt's affect on yellow corn crop yield is therefore highly relevant to food security.

Bt-corn is a genetically modified crop engineered to express the Cry1Ab gene from the bacterium *Bacillus thuringiensis* (Bt), enabling it to produce the Cry1Ab protein—a δ-endotoxin toxic to specific lepidopteran larvae like the Asian corn borer (Bessin, 2017; Pray, 2008). This gene is inserted into the corn genome using plasmid vectors, enabling the plant to produce the Bt toxin throughout its tissues (Figure 1; Figure 2). When ingested by target insects, the toxin binds to receptors in the insect's gut, disrupting digestion and causing death. This built-in pest resistance reduces the reliance on chemical insecticides, lowering production costs and minimising environmental impact (Krishna & Qaim, 2012). As a GMO, Bt-corn offers enhanced crop-protection and can lead to improved yields.

Increasing agricultural output requires a range of strategies, including technological and biological interventions (Mutuc et al., 2011). Among these, insect-resistant genetically modified (GM) crops such as Bt-corn are among the most widely adopted worldwide. Their popularity has led to extensive research on their effectiveness in improving yields and reducing pesticide use. However, for the purpose of this investigation, the focus of 'viable option' will be limited to biological strategies that directly maintain food production, specifically the implementation of Bt-corn to increase crop yield.

Further, while broader definitions of 'maintaining food production' include factors like food safety, equipment and efficiency, and sanitation (Muhie, 2022), this investigation defines it solely in terms of maximising yield by minimising pest-related losses through Bt-corn cultivation.

Research Question: Does Bt-corn produce a greater crop yield than conventional non-Bt corn?

The following excerpts have been included to demonstrate *thorough* identification of *relevant* trends using *justified* scientific arguments for an AS Unit 2 research question.

Note: The characteristic/s identified may not be the only time the characteristic/s occurred throughout a response.

Excerpt 1

Research Question

With the rise of MRSA and E. coli (antibiotic-resistant bacteria), could bacteriophages be an effective safe treatment for these dangerous bacterial infections in a post-antibiotic world?

Excerpt 2

In Graph 1, it can be observed that in (A), the initial E.coli levels (VRB Controlled), were at 7.2 $\log_{10}$ CFU/mL, (15.85 million bacteria per mL). Once the ciprofloxacin was added, there was a 1.7 Log reduction, meaning that there are now 5.5 $\log_{10}$ CFU/mL or (316,227 CFU/mL) which is a 98% decrease in E.coli count using the antibiotics. However, it can be seen that with M17, there was a 74.88% decrease from 8.1 $\log_{10}$ CFU/mL, (125.9 million bacteria per mL) to 7.5 $\log_{10}$ CFU/mL, (31.62 million bacteria per mL) using ciprofloxacin. This means that the ciprofloxacin is effective at killing the E.coli but at the cost of healthy bacteria. Using the bacteriophage cocktail, there was a 99.93% decrease in E.coli from 7.2 $\log_{10}$ CFU/mL, (15.85 million bacteria per mL) to 4 $\log_{10}$ CFU/mL, (10 000 bacteria per mL) as seen in VRB Controlled, (A). With M17, there was a 151.18% increase from 8.1 $\log_{10}$ CFU/mL, (125.9 million bacteria per mL) to 8.5 $\log_{10}$ CFU/mL, (316.23 million bacteria per mL) using the bacteriophage cocktail. Hence, the bacteriophages didn't kill any of the beneficial bacteria, and thus, they were left to grow; this explains the 151.18% increase. This indicates that bacteriophages are specific to the bacteria they target; meaning that unlike antibiotics, they will only attack the bacteria they are programmed to attack.

Excerpt 3

In Graph 2, it can be observed that there is a uniform increase in antibody levels across all 20 patients. However, each antibody response is unique, making it slightly unpredictable however, this is expected due to individual variations in immune system sensitivity caused by genetics or prior exposure to similar antigens **(Nature, 2023)**. This explains why patient 4 had an antibody count of 670 Au whereas patient 18 had an antibody count of 30 Au. The immune response to the phage treatment supports the idea that bacteriophages act as antibacterial agents and moderate the immune system. Enhancing the body's ability to recognise and respond to bacterial antigens including MRSA and potentially E.coli.

Excerpt 4

In Graph 3, the Y-axis is the ratio of Shiga toxin gene (gene that tells E.coli to release harmful toxins) levels after 7.5 hours compared to the starting point (0 hours). The X-axis shows cells infected and uninfected by lytic phages (p000v, p000y). It can be observed that with the uninfected cells the toxin gene levels increased to about 8, while cells treated with phages p000v and p000y only reached about 0.5-1. This means that without the phage treatment, E.coli produces significantly more toxins (about 8x more after 7.5 hours). When treated with phages p000v or p000y, the increase is much smaller (about 0.5-1x); demonstrating the potential for phages to help stop bacteria from making dangerous toxins.

The following excerpt demonstrates a *justified discussion* of the quality of evidence for a Unit 4 research question, and improvements and extensions that are *considered and relevant* to the claim.

Note: The characteristic/s identified may not be the only time the characteristic/s occurred throughout a response.

Brookes & Dinh (2020) and Sanglestsawai et al. (2017) both identify the limitation of using cross-sectional datasets from single crop years (2018/2019, 2003/2004, and 2007/2008), rather than panel data that tracks farms over time. As a result, their analyses cannot account for long-term or seasonal factors—such as year-to-year weather changes, evolving farming practices, or cumulative pest resistance—that may influence yield. This limits the validity of the studies, as they may overlook variables that affect the relationship between Bt-corn and yield. These limitations reduce the scope of the conclusions, as they only reflect short-term outcomes rather than Bt-corn's sustained impact on yield over time.

Additionally, 63 of 470 surveys (13%) from the 2003/2004 crop year were excluded due to incomplete responses (Sanglestsawai et al., 2017)—exceeding the commonly accepted 10% threshold for missing data in survey-based studies (Yeatts & Martin, 2015). Although this threshold is context-dependent and not all missing data introduces bias, exceeding it increases the risk that the excluded responses were non-random. If farmers with atypically high or low yields were disproportionately represented among incomplete responses, the resulting dataset may no longer accurately represent the broader population. This potential selection bias decreases the validity of the findings, while the volume of missing data reduces the overall reliability of the evidence—thereby decreasing the reliability of conclusions drawn regarding Bt-corn's effect on yield.

Moreover, Sanglestsawai et al.'s (2017) findings were highly sensitive to environmental conditions: yields were higher in crop year 2003/2004, a year with favourable weather, but declined in 2007/2008, a year which experienced drought and regional flooding (Yumul et al., 2010). This variability reduced the accuracy and reliability of the yield results, as Bt-corn's performance may not be consistent under different conditions. Consequently, the validity and generalisability of the conclusions is decreased, narrowing the scope of the research question's answer.

To reduce the influence of weather anomalies, such as the dry spell and excessive rainfall in 2007/2008 (Sanglestsawai et al., 2017), an improvement would be to source and incorporate data from multiple locations and crop years across varying climatic conditions. This would improve validity by minimising the impact of outlier events and better representing Bt-corn's average yield performance across diverse environments. In doing so, it would increase the reliability and generalisability of conclusions regarding Bt-corn's effectiveness, thereby strengthening the evidence for genetic modification as a viable option for maintaining food production under real-world agricultural conditions.

Overall, the findings support the claim that 'genetic modification is a viable option for maintaining food production', when defined as Bt-corn's maximisation of crop yield. However, this investigation is limited in scope relative to the claim, focusing only on one biological strategy (Bt technology) and one outcome (crop yield), rather than the broader range of factors involved in maintaining food production. This limits the overall applicability of the claim.

Thus, a valuable extension would be to broaden the definition of 'genetic modification' to include other organisms, such as genetically modified salmon. This shifts the context from crop-based to animal-based food production, allowing the investigation to explore the viability of genetic modification across multiple sectors (Government of Western Australia, 2019). Expanding the scope in this way would allow for a more comprehensive evaluation of the claim, improving the claim's real-world relevance and its validity and applicability.

Additionally, the definition of 'maintaining food production' stated in the rationale could be extended beyond yield to include nutritional quality. For example, GM crops like Golden Rice aim to address micronutrient deficiencies by enhancing vitamin A content (International Rice Research Institute, 2018). This extension increases the investigation's scope, providing a more holistic view of food production, strengthening the investigation's reliability by evaluating multiple outcomes—such as health impact alongside yield—and improving the claim's relevance and applicability to global food security.

The following excerpt demonstrates *extrapolation of credible* findings to the claim that gene therapy offers a viable solution for the prevention and treatment of human diseases. The response clearly summarises *credible* findings before extending them to the claim, recognising limitations of their applicability.

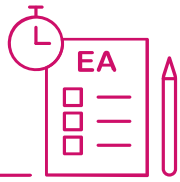
Note: The characteristic/s identified may not be the only time the characteristic/s occurred throughout a response.

In vivo Gene replacement therapy via scAAV9-hSGSH, by the implied activity of heparan-N-sulfatase, does reduce glycosaminoglycan-content in MPSIIIA mammals, based on empirical, statistically significant evidence from murine studies (Fu, Cataldi, Ware, & Zaraspe, 2016) and (Bobo, Samowitz, Robin, & Fu, 2020).

Evidence 1 found reduced GAG-content in scAAV9-hSGSH treated compared to diseased cohorts at both 8-months-pi and the humane endpoint, with statistically significant differences ($P<0.05$) in six somatic tissues. Evidence 2 corroborated this relationship between treatment and GAG-contents reduction, revealing a total of seven tissues, at either 8-months-pi or endpoint, where glycosaminoglycans (GAG-content) was statistically significantly lower in cohorts treated by scAAV9-h-SGSH gene replacement therapy. This reduction in the GAG storage phenotype resulted from the gene-mediated heparan-N-sulfatase enzyme's metabolic function, suggesting sufficient gene expression in patient cells.

This research, however, does not fully support the claim, for whilst the finding of decreased GAG-content following gene therapy treatment is relevant in that it evidences active heparan-N-sulfatase, and thus correction of the MPSIIIA disease phenotype, the exclusive study of murine models produces results which cannot, due to transitional complications posed by the differential biological systems, be directly extrapolated to a viable treatment using scAAV9-delivery in vivo gene replacement therapy in human cases of MPSIIIA. As a result, the ability of these findings to be translated to clinical trials is severely limited, with potential immune responses and challenges of high vector dosage cited as potential barriers to human application. Furthermore, the correlation between gene therapy and reduced GAG-contents relates solely to vector-administered gene therapy for MPSIIIA, thus neglecting the potential of gene therapy delivered by other vectors or lipid-nanoparticles/stem cells to prevent/treat MPSIIIA and other human diseases.

External assessment



External assessment (EA) is developed and marked by the QCAA. The external assessment for a subject is common to all schools and administered under the same conditions, at the same time, on the same day. The external assessment papers and the EAMG are published in the year after they are administered.

Examination (50%)

Assessment design

The assessment instrument was designed using the specifications, conditions and assessment objectives described in the summative external assessment section of the syllabus.
The examination consisted of two papers:

- Paper 1, Section 1 consisted of multiple choice questions (20 marks)
- Paper 1, Section 2 consisted of short response questions (29 marks)
- Paper 2, Section 1 consisted of short response questions (52 marks)

The AS assessment instrument was designed using the specifications, conditions and assessment objectives described in the summative external assessment section of the AS.
The AS examination consisted of two papers:

- Paper 1, Section 1 consisted of multiple choice questions (20 marks)
- Paper 1, Section 2 consisted of short response questions (23 marks)
- Paper 2, Section 1 consisted of short response questions (45 marks)

Assessment decisions

Assessment decisions are made by markers by matching student responses to the external assessment marking guide (EAMG).

Multiple choice question responses

There were 20 multiple choice questions.

Percentage of student responses to each option

Note:

The correct answer is **bold** and in a blue shaded table cell.

Some students may not have responded to every question.

Biology General

Question	A	B	C	D
1	12.20	3.24	**81.83**	2.44
2	27.11	**57.91**	7.52	6.76
3	4.10	5.40	**45.98**	44.15
4	6.65	**52.97**	32.38	7.64
5	22.94	31.84	34.76	**10.03**
6	3.04	35.69	13.22	**47.52**
7	**41.30**	14.53	36.95	6.83
8	14.72	18.20	**39.00**	27.72
9	7.28	**58.99**	31.79	1.59
10	23.32	26.53	**42.08**	7.60
11	6.89	6.54	**76.67**	9.50
12	**56.93**	31.07	2.29	9.38
13	5.17	6.71	**83.54**	4.28
14	21.71	4.08	**55.52**	18.32
15	12.52	**74.93**	4.18	7.91
16	**42.50**	13.00	15.92	27.91
17	**65.45**	17.25	3.72	13.25
18	13.16	9.92	**49.44**	27.06
19	7.85	28.27	15.44	**48.13**
20	**86.72**	9.53	0.80	2.64

Biology AS

Question	A	B	C	D
1	**68.32**	27.80	2.37	1.08
2	13.58	**84.05**	1.51	0.86
3	9.27	12.28	10.13	**68.10**
4	4.74	16.38	42.24	**36.42**
5	**33.19**	13.15	13.36	39.87
6	9.48	**42.24**	36.21	11.64
7	5.82	7.54	27.37	**59.05**
8	**58.84**	13.58	15.30	11.85
9	**14.01**	32.97	13.79	39.01
10	10.78	19.18	**63.36**	6.68
11	18.10	7.33	11.85	**62.50**
12	11.85	**66.38**	9.05	12.50
13	9.27	8.19	**69.83**	12.28

Question	A	B	C	D
14	21.12	3.66	**71.34**	3.88
15	12.28	**52.59**	16.16	18.53
16	1.08	**21.12**	8.62	68.97
17	**51.51**	8.19	8.84	31.47
18	9.70	**57.33**	12.72	20.26
19	1.29	13.15	**85.13**	0.43
20	17.89	19.83	**61.42**	0.86

Effective practices

Overall, students responded well when they:

- identified unknown values from graphs
- interpreted data from graphs and tables, e.g.
  - inferring species relatedness from molecular data
  - determining genetic conditions from a karyotype
  - interpreting ecological field data
  - inferring if a population had reached carrying capacity
  - drawing conclusions about the effectiveness of different control measures in limiting the spread of disease (AS)
- made simple calculations, e.g.
  - applying the Lincoln index to determine the size of a population
  - predicting the size of a population using quadrat data
- demonstrated knowledge of enzymes involved in DNA replication
- demonstrated understanding of species interactions.

Practices to strengthen

When preparing students for external assessment, it is recommended that teachers:

- provide opportunities for students to practise describing and explaining concepts, theories, models and systems under examination conditions, e.g.
  - describing key features of the Linnaean system of biological classification
  - describing how climax communities differ from pioneer communities
  - describing the structure of plasmids and their role in making recombinant DNA
  - describing how pathogens are recognised as non-self and trigger a humoral immune response (AS)
  - explaining how light-dependent and light-independent photosynthesis reactions work together to produce glucose (AS)
- provide opportunities for students to practise integrating knowledge and understanding of the syllabus subject matter to explain phenomena, e.g.

  - explaining why molecular sequence data is often more accurate than anatomical data for determining the relatedness of different species
  - explaining population changes using the principles of natural selection
  - explaining why genetic drift is usually high in populations affected by bottlenecks
  - explaining how transcription factors allow for cell differentiation
  - explaining how kleptothermy helps maintain homeostasis (AS)
- ensure students use and interpret subject-specific terminology correctly, e.g. ‘sex chromosome’ versus ‘sex cell’; ‘population growth’ versus ‘population growth rate’; ‘negative feedback’ versus ‘homeostasis’
- include activities that develop proficiency in the numeracy aspects of the course, such as rearranging equations, calculating percentages and determining ratios.

Samples

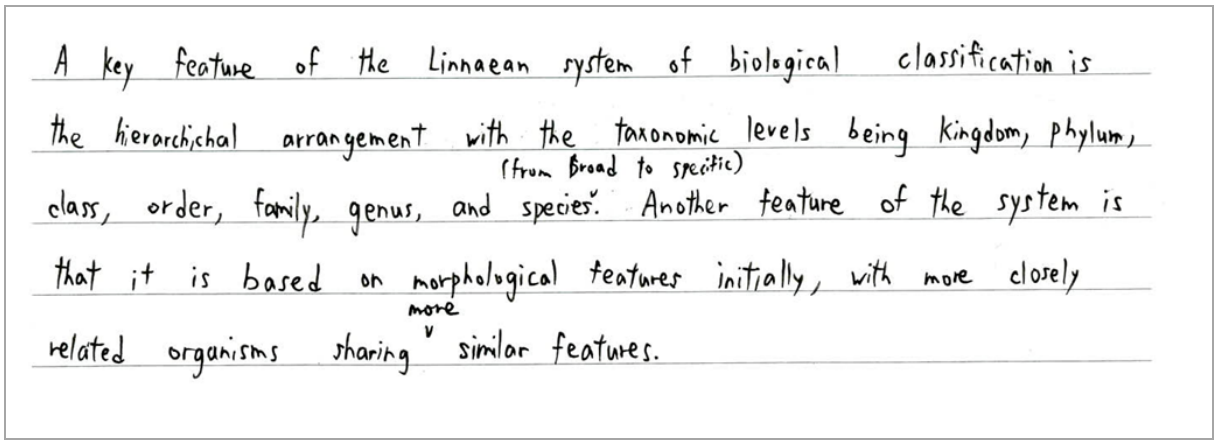
Short response

Question 21a) from Paper 1 of the Biology General examination

This question required students to describe two key features of the Linnaean system of biological classification.

Effective student responses provided an account of two features.

This excerpt has been included to demonstrate an appropriate response to a *describe* item. The student has provided an appropriate account of the system, making two key features evident.


A key feature of the Linnaean system of biological classification is the hierarchichal arrangement with the taxonomic levels being kingdom, phylum, class, order, family, genus, and species. (from broad to specific) Another feature of the system is that it is based on morphological features initially, with more closely related organisms sharing more similar features.

Short response

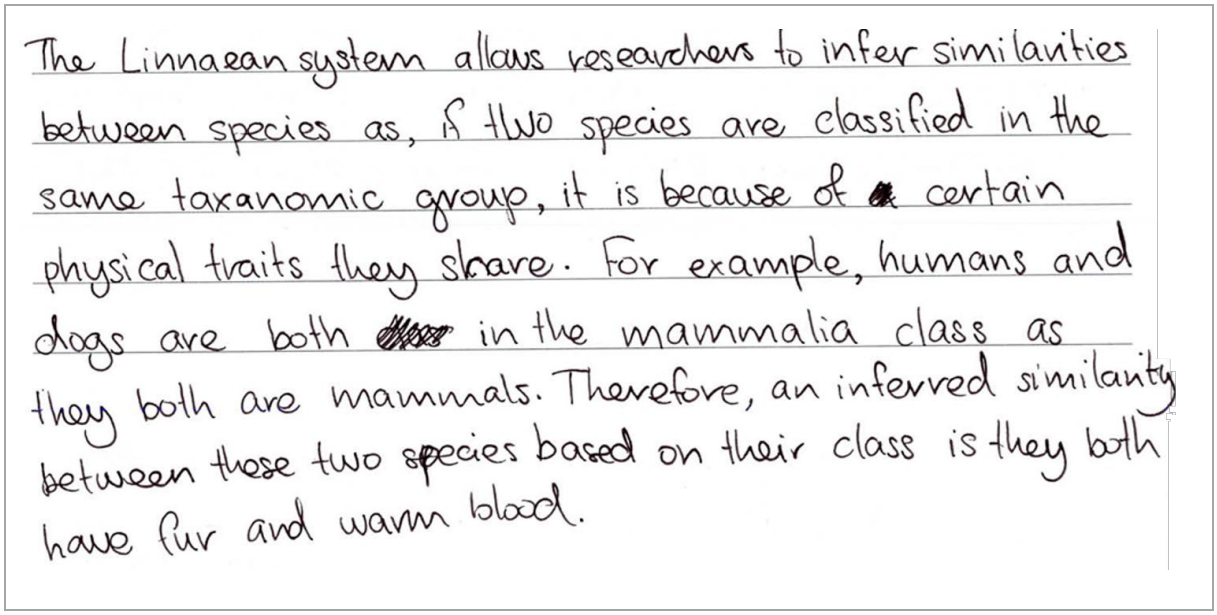
Question 21b) from Paper 1 of the Biology General examination

This question required students to explain how the Linnaean system allows researchers to infer similarities between species, using an example.

Effective student responses:

- explained how the Linnaean system allows researchers to infer similarities between species
- provided an example.

This excerpt has been included to demonstrate effective application of subject matter knowledge in an examination context and appropriate use of subject-specific terminology to convey understanding.


The Linnaean system allows researchers to infer similarities between species as, if two species are classified in the same taxanomic group, it is because of certain physical traits they share. For example, humans and dogs are both in the mammalia class as they both are mammals. Therefore, an inferred similarity between these two species based on their class is they both have fur and warm blood.

Short response

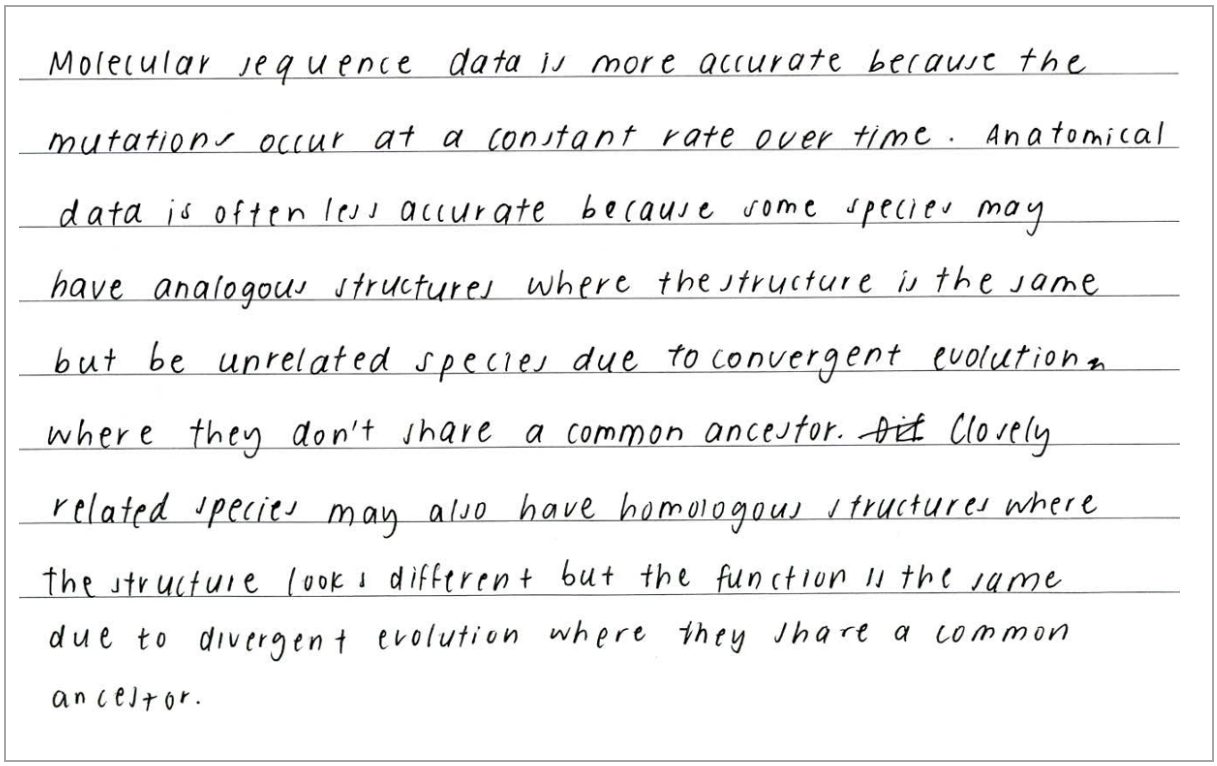
Question 25c) from Paper 1 of the Biology General examination

This question required students to use their knowledge of convergent and divergent evolution to explain why molecular sequence data is often more accurate than anatomical data for determining the relatedness of different species.

Effective student responses:

- distinguished between divergent and convergent evolution
- explained the difference in accuracy.

This excerpt has been included to demonstrate effective application of subject matter knowledge with consideration of key terms in the question and engagement with relevant stimulus to develop a response. The response uses subject-specific terminology to convey understanding.



Molecular sequence data is more accurate because the mutations occur at a constant rate over time. Anatomical data is often less accurate because some species may have analogous structures where the structure is the same but be unrelated species due to convergent evolution where they don't share a common ancestor. ~~Dif~~ Closely related species may also have homologous structures where the structure look's different but the function is the same due to divergent evolution where they share a common ancestor.

Short response

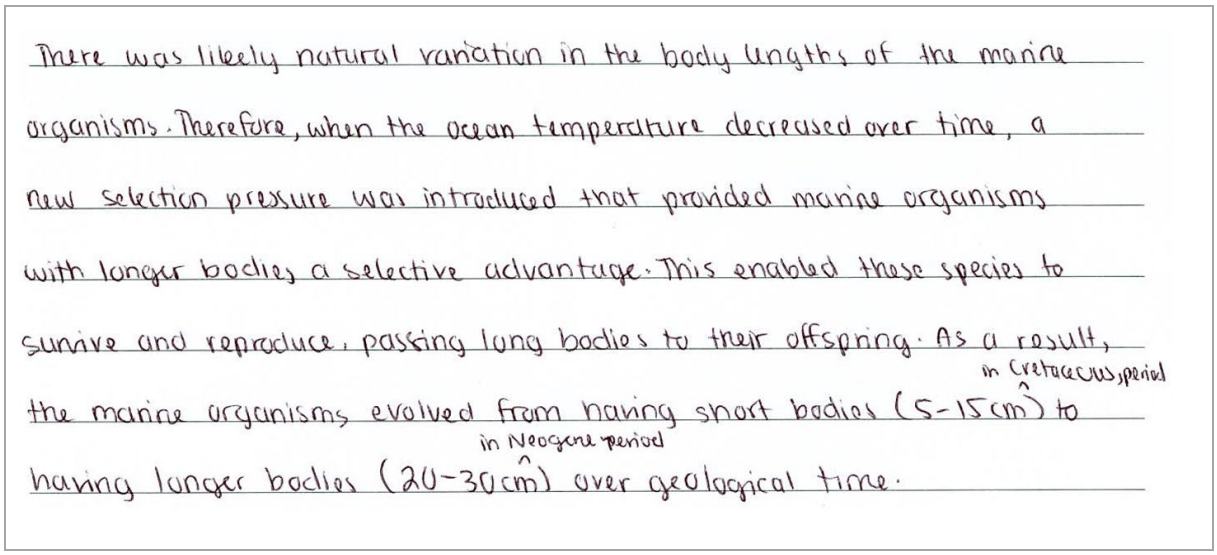
Question 26c) from Paper 1 of the Biology General examination

This question required students to use the principles of natural selection to explain the trend in body length of marine organisms over geological time. The item was supported by a graph showing how body length and ocean temperature changed over time.

Effective student responses:

- explained the observed trends, referring to all of the following
  - phenotypic variation
  - differential survival and reproduction
  - change over time.

This excerpt has been included to demonstrate consideration of the cognitive verb, number of marks, key terms in the question and relevant stimulus to develop an appropriate response. Understanding of the principles of natural selection is demonstrated through logical sequencing of ideas and effective linking to the context.



There was likely natural variation in the body lengths of the marine organisms. Therefore, when the ocean temperature decreased over time, a new selection pressure was introduced that provided marine organisms with longer bodies a selective advantage. This enabled these species to survive and reproduce, passing long bodies to their offspring. As a result, the marine organisms evolved from having short bodies (5-15cm in Cretaceous period) to having longer bodies (20-30cm in Neogene period) over geological time.

Short response

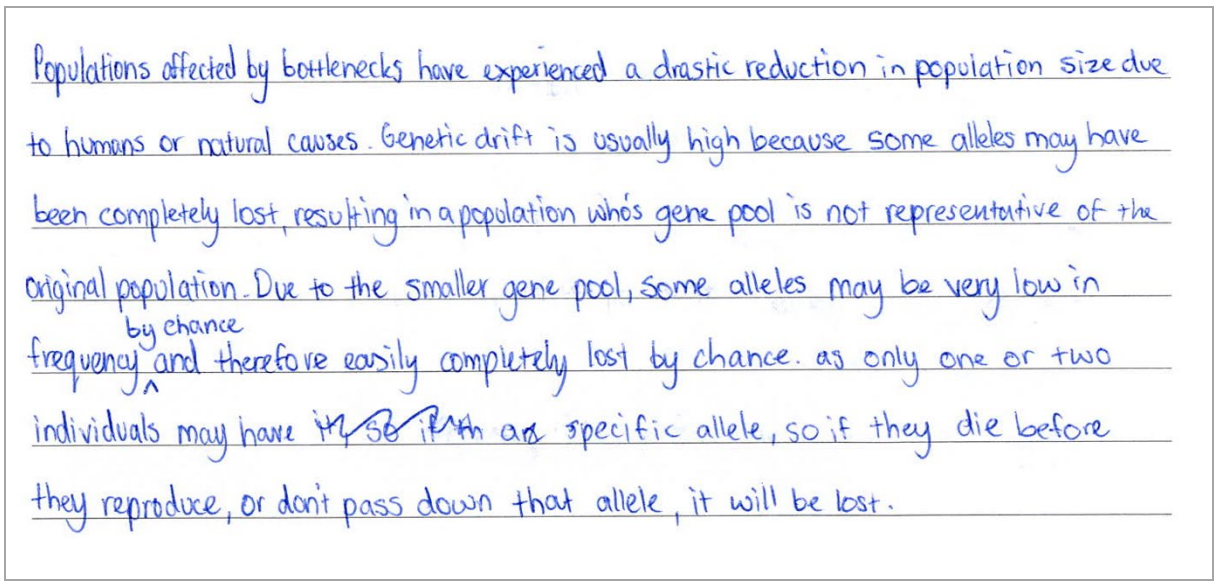
Question 1 from Paper 2 of the Biology General examination

This question required students to explain why genetic drift is usually high in populations affected by bottlenecks.

Effective student responses:

- recognised that a bottleneck reduces the size of a population
- explained why genetic drift is higher in populations affected by bottlenecks.

This excerpt has been included to demonstrate effective application of subject matter knowledge to explain phenomena in an examination context, and appropriate use of subject-specific terminology to convey understanding.


Populations affected by bottlenecks have experienced a drastic reduction in population size due to humans or natural causes. Genetic drift is usually high because some alleles may have been completely lost, resulting in a population who's gene pool is not representative of the original population. Due to the smaller gene pool, some alleles may be very low in frequency by chance and therefore easily completely lost by chance. as only one or two individuals may have ~~it so if th~~ a specific allele, so if they die before they reproduce, or don't pass down that allele, it will be lost.

Short response

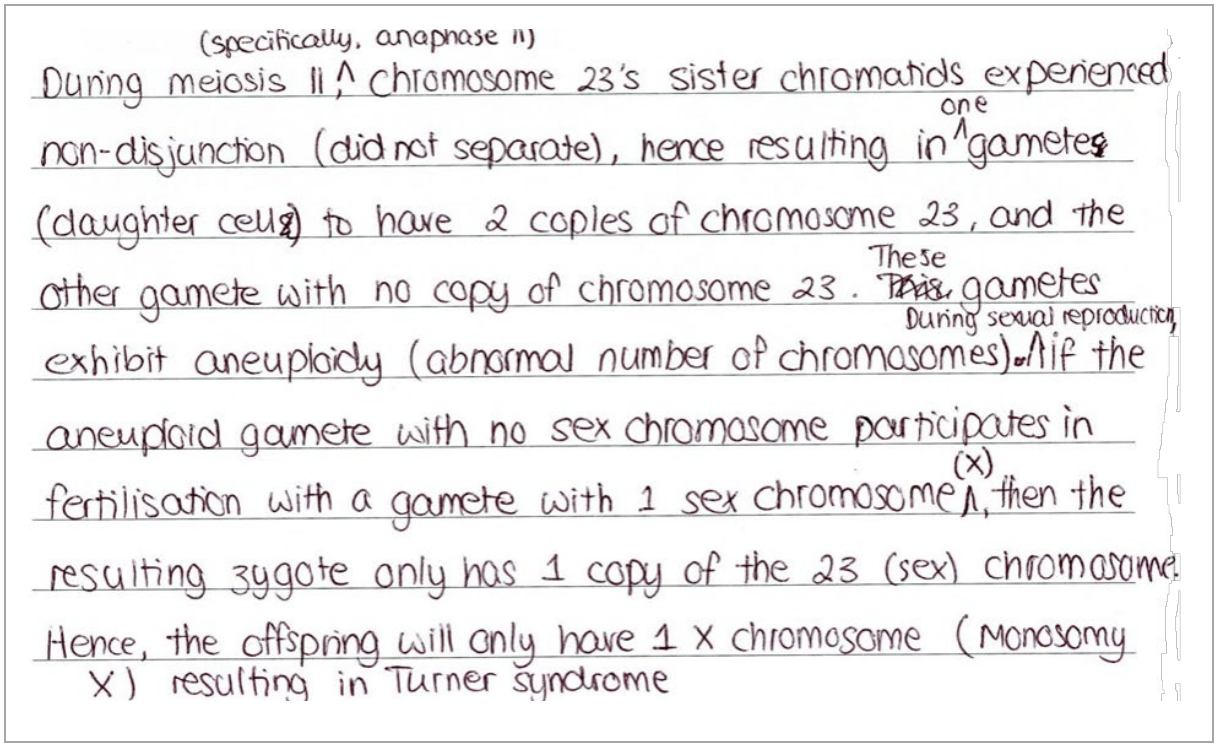
Question 2b) from Paper 2 of the Biology General examination

This question required students to explain how errors in meiosis may have led to a condition indicated in a karyotype.

Effective student responses:

- recognised the condition is due to non-disjunction
- described non-disjunction
- explained how non-disjunction leads to Turner syndrome (Monosomy X).

This excerpt has been included to show effective engagement with the stimulus to develop an appropriate response. The response refers directly to features in the stimulus, rather than making generalised statements about aneuploidy.


(specifically, anaphase II)
During meiosis II, chromosome 23's sister chromatids experienced non-disjunction (did not separate), hence resulting in one gamete (daughter cell) to have 2 copies of chromosome 23, and the other gamete with no copy of chromosome 23. These gametes exhibit aneuploidy (abnormal number of chromosomes). During sexual reproduction, if the aneuploid gamete with no sex chromosome participates in fertilisation with a gamete with 1 sex chromosome (X), then the resulting zygote only has 1 copy of the 23 (sex) chromosome. Hence, the offspring will only have 1 X chromosome (Monosomy X) resulting in Turner syndrome

Short response

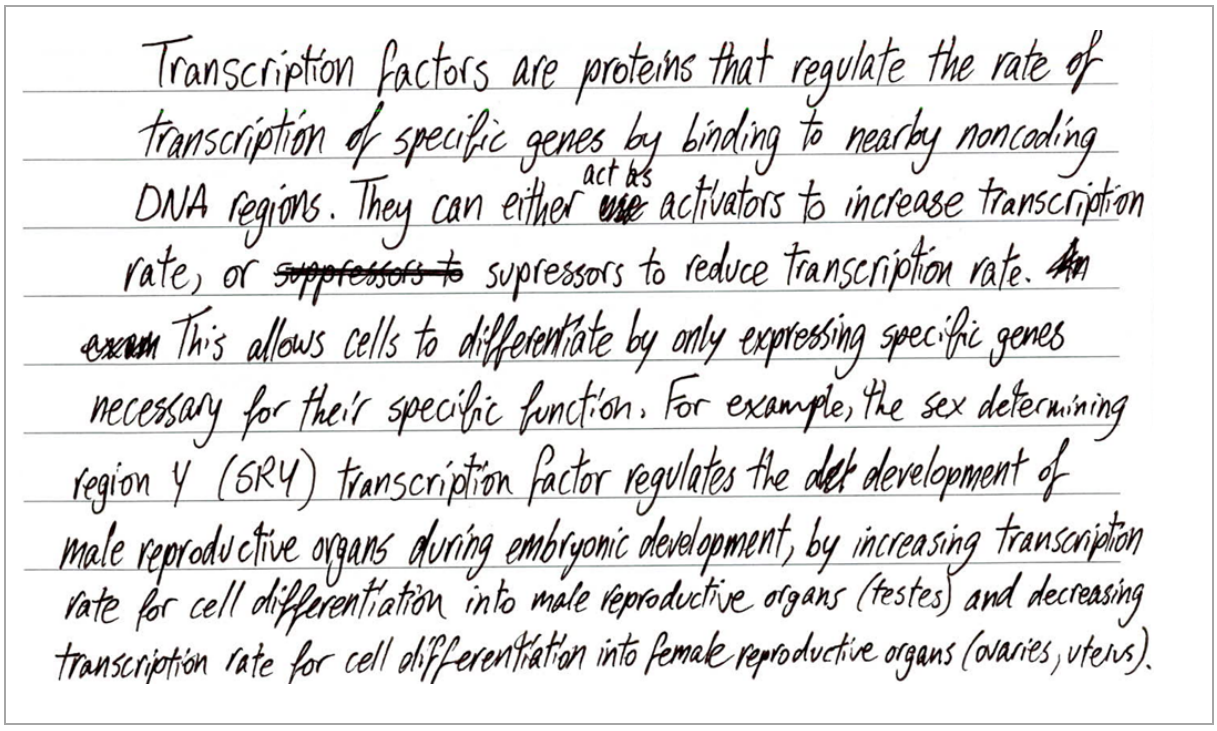
Question 4 from Paper 2 of the Biology General examination

This question required students to explain how transcription factors allow for cell differentiation, using an example.

Effective student responses:

- recognised that transcription factors bind to specific DNA sequences
- explained that this allows different genes to be expressed in different cell types
- provided an example.

This excerpt has been included to demonstrate effective integration of subject matter knowledge to explain phenomena in an examination context, and effective use of subject-specific terminology to convey understanding.


Transcription factors are proteins that regulate the rate of transcription of specific genes by binding to nearby noncoding DNA regions. They can either ~~use~~ act as activators to increase transcription rate, or ~~suppressors to~~ supressors to reduce transcription rate. ~~An~~ ~~exam~~ This allows cells to differentiate by only expressing specific genes necessary for their specific function. For example, the sex determining region Y (SRY) transcription factor regulates the ~~dek~~ development of male reproductive organs during embryonic development, by increasing transcription rate for cell differentiation into male reproductive organs (testes) and decreasing transcription rate for cell differentiation into female reproductive organs (ovaries, uterus).

Short response

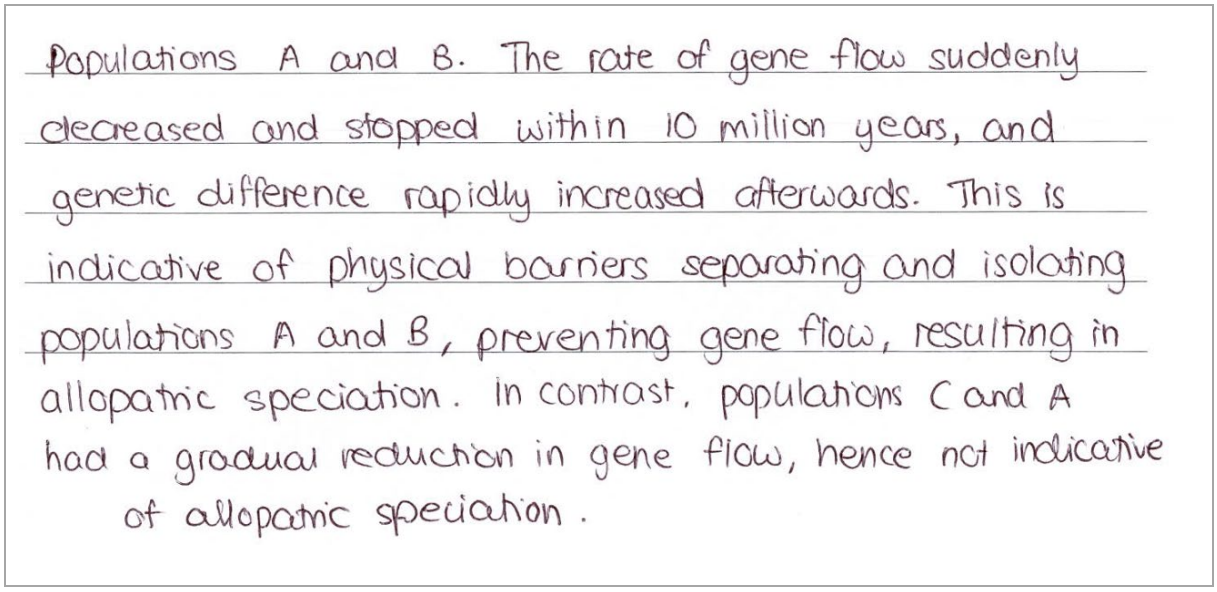
Question 9 from Paper 2 of the Biology General examination

This question required students to infer which populations underwent allopatric speciation, based on graphs showing how gene flow and genetic difference changed over time.

Effective student responses:

- inferred population A and B
- provided appropriate justification.

This excerpt has been included to demonstrate an appropriate response to an *infer* item. The response states a conclusion and supports it with reasoning and evidence.


Populations A and B. The rate of gene flow suddenly decreased and stopped within 10 million years, and genetic difference rapidly increased afterwards. This is indicative of physical barriers separating and isolating populations A and B, preventing gene flow, resulting in allopatric speciation. In contrast, populations C and A had a gradual reduction in gene flow, hence not indicative of allopatric speciation.

Short response

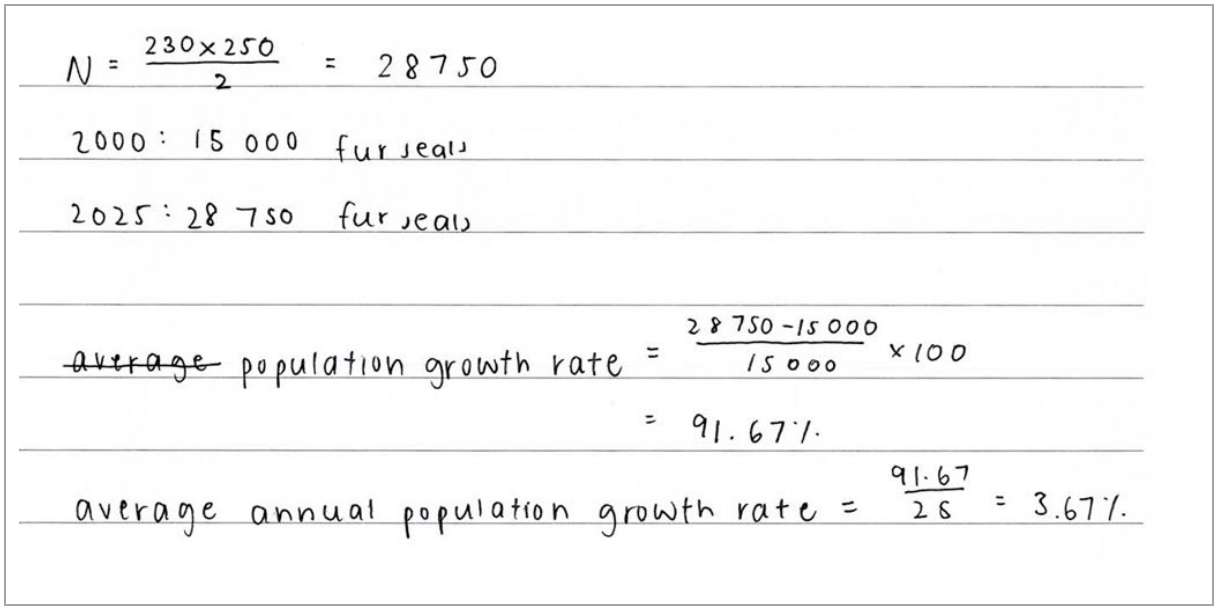
Question 10e) from Paper 2 of the Biology General examination

This question required students to use population data to determine the average annual population growth rate.

Effective student responses:

- calculated the number of organisms
- determined growth rate
- determined average annual population growth rate.

This excerpt has been included to demonstrate an appropriate response to an item requiring a multi-step calculation, including the provision of full working.



Short response

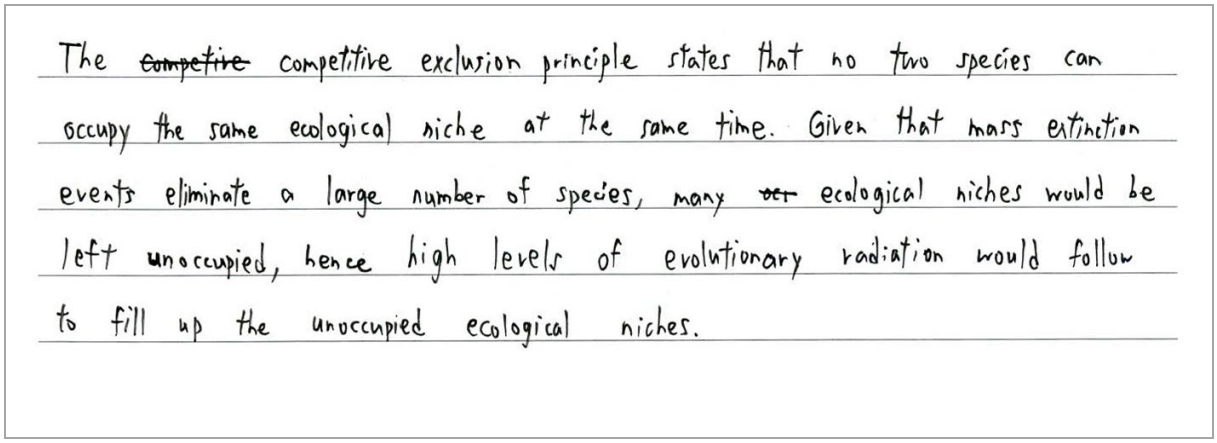
Question 11c) from Paper 2 of the Biology General examination

This question required students to use the competitive exclusion principle to explain why mass extinctions are often followed by evolutionary radiation.

Effective student responses:

- described the competitive exclusion principle
- explained that mass extinctions create new niches.

This excerpt has been included to demonstrate effective engagement with key terms in the question and integration of subject matter knowledge to explain phenomena.



Short response

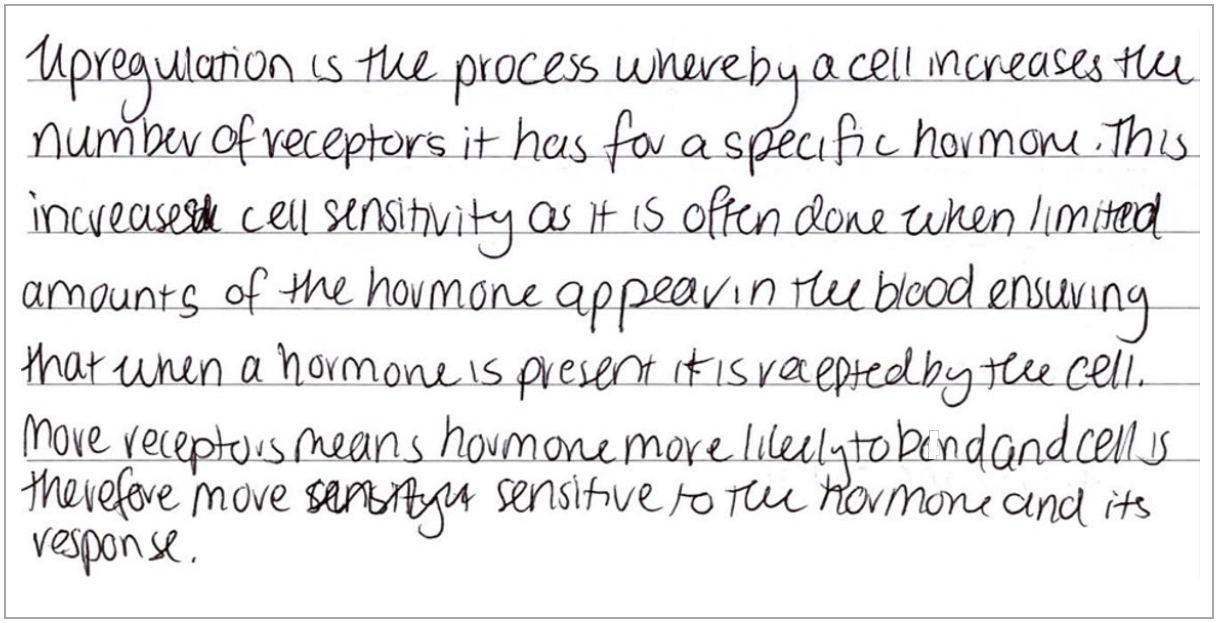
Question 3 from Paper 2 of the Biology AS examination

This question required students to explain upregulation and its effect on cell sensitivity to hormones.

Effective student responses:

- described upregulation
- explained the effect on cell sensitivity.

This excerpt has been included to demonstrate an appropriate response to an *explain* item for AS Unit 2. The response makes the relationship between number of receptors and cell sensitivity clear.


Upregulation is the process whereby a cell increases the number of receptors it has for a specific hormone. This increased cell sensitivity as it is often done when limited amounts of the hormone appear in the blood ensuring that when a hormone is present it is accepted by the cell. More receptors means hormone more likely to bind and cell is therefore more sensitive to the hormone and its response.

Short response

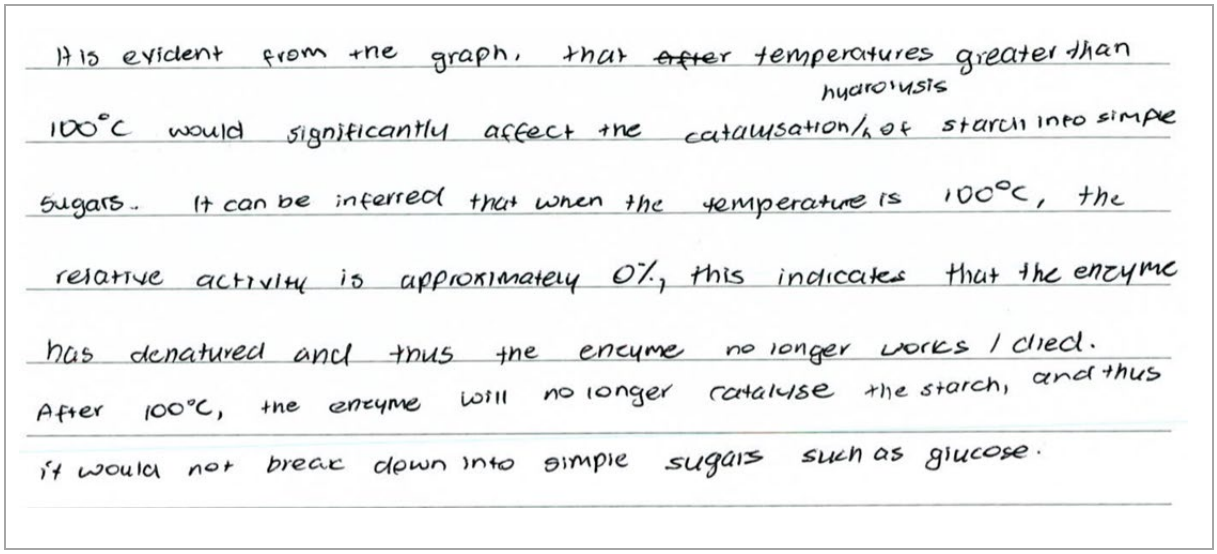
Question 25d) from Paper 1 of the Biology AS examination

This question required students to predict how the hydrolysis of starch would be affected by temperatures greater than 100 °C, using information in a graph.

Effective student responses:

- predicted hydrolysis of starch would stop
- provided reasoning
- provided evidence from the graph that relative activity of amylase is 0% at 100 °C

This excerpt has been included to demonstrate an appropriate response to a *predict* item for AS Unit 1. The response states a conclusion and supports it with reasoning.


It is evident from the graph, that ~~after~~ temperatures greater than 100°C would significantly affect the catalysation/hydrolysis of starch into simple sugars. It can be inferred that when the temperature is 100°C, the relative activity is approximately 0%, this indicates that the enzyme has denatured and thus the enzyme no longer works / died. After 100°C, the enzyme will no longer catalyse the starch, and thus it would not break down into simple sugars such as glucose.

Short response

Question 6c) from Paper 2 of the Biology AS examination

This question required students to explain why the size of a cell is limited by the relationship between the surface area to volume ratio (SA:V) and the rate of diffusion.

Effective student responses:

- identified that as cell size increases, SA:V decreases
- identified that as SA:V decreases, diffusion of substances becomes insufficient
- explained that cell size is limited by the diffusion rate meeting the requirements of cells.

This excerpt has been included to demonstrate an appropriate response to an *explain* item for AS Unit 1. The response clearly states the relationship and reasons linked to the context.