Biology subject report

2024 cohort

January 2025

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 2024 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 2025.

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.

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

448
schools offered Biology

86.16%
agreement with provisional marks for IA2

98.46%
of students received a C or higher

Subject data summary
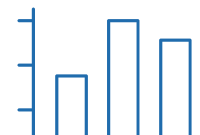
Subject completion

The following data includes students who completed the General subject or AS.

Note: All data is correct as at January 2025. 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: 448.

Completion of units	Unit 1	Unit 2	Units 3 and 4
Number of students completed	16,655	15,394	13,795

Units 1 and 2 results

Number of students	Satisfactory	Unsatisfactory
Unit 1	15,533	1,122
Unit 2	14,104	1,290

Units 3 and 4 internal assessment (IA) results

Total marks for IA
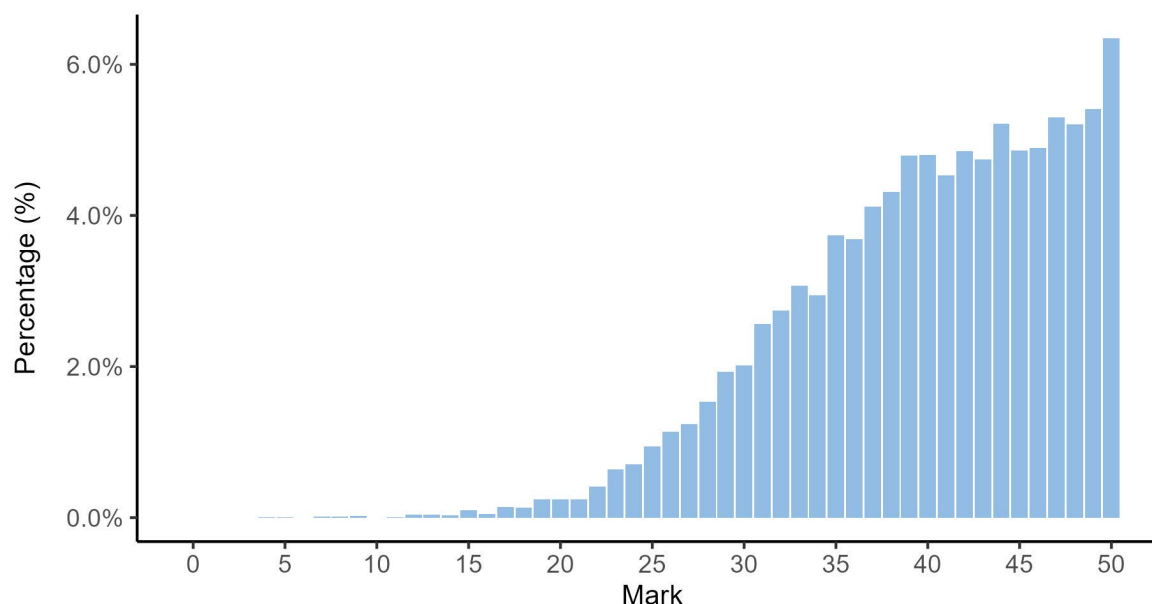
IA1 marks

IA1 total
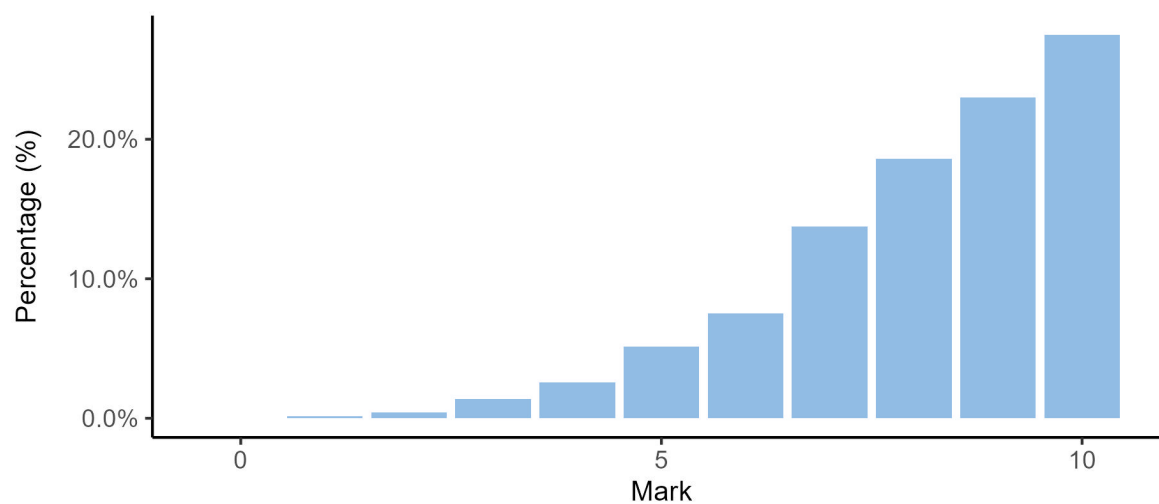
IA1 Criterion: Data test
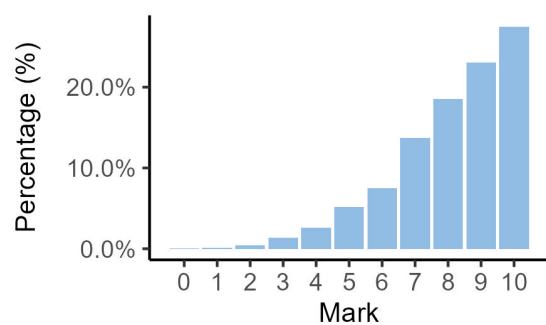
IA2 marks

IA2 total
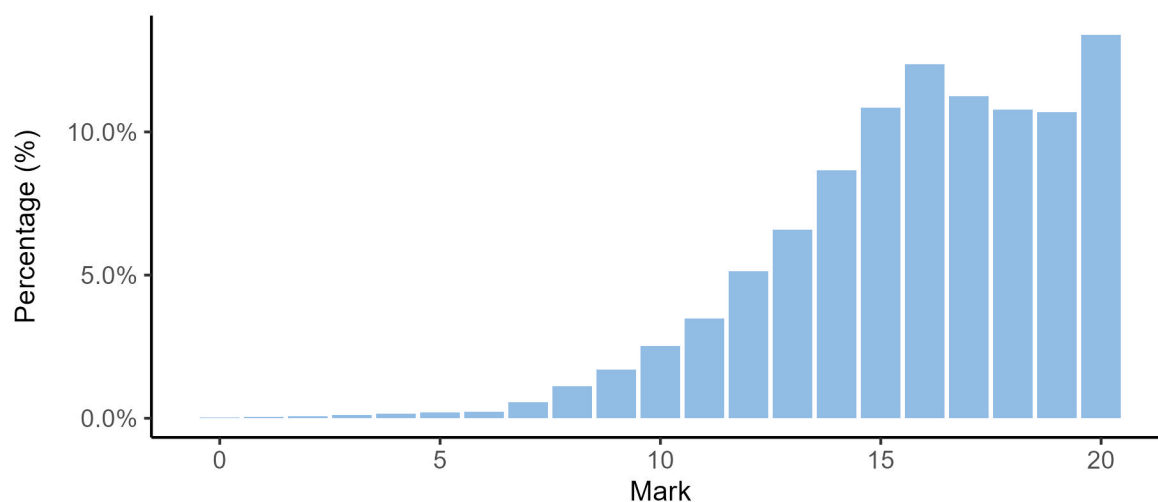
IA2 Criterion: Research and planning
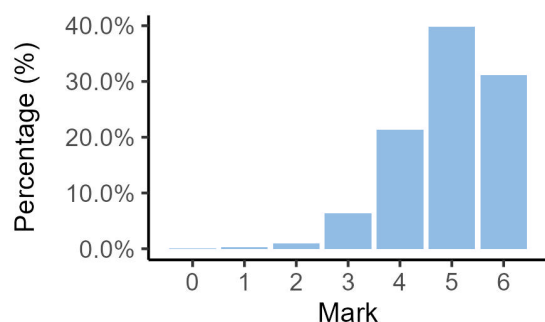
IA2 Criterion: Analysis of evidence
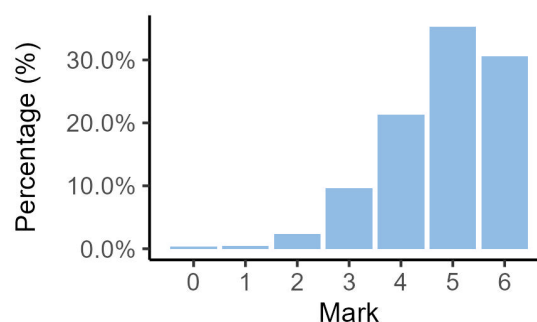
IA2 Criterion: Interpretation and evaluation
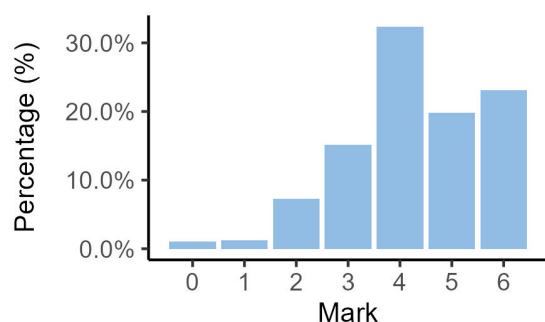
IA2 Criterion: Communication
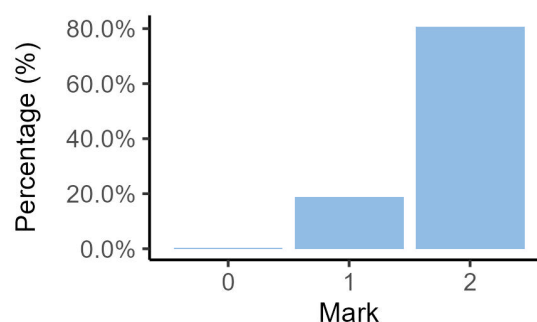
IA3 marks

IA3 total
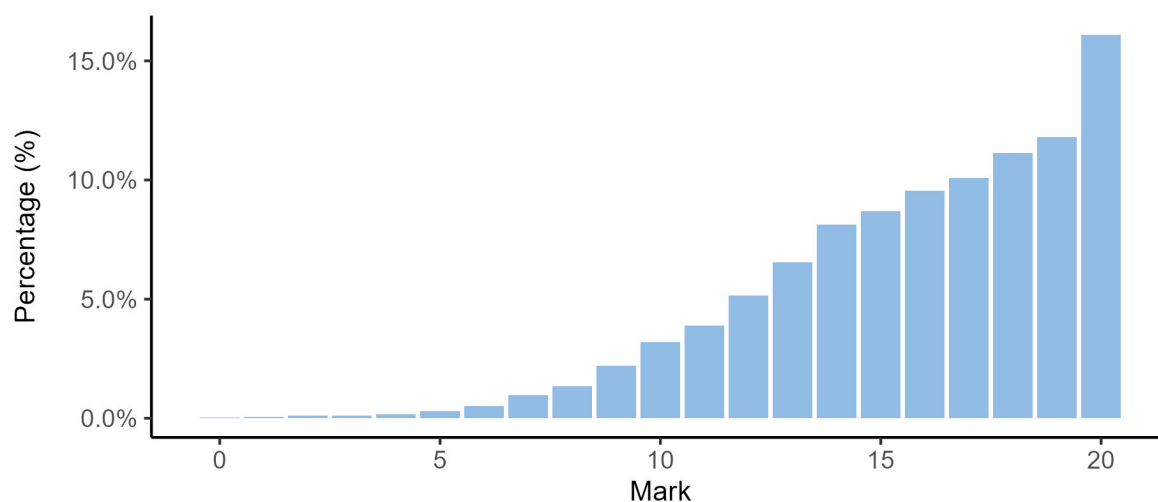
IA3 Criterion: Research and planning
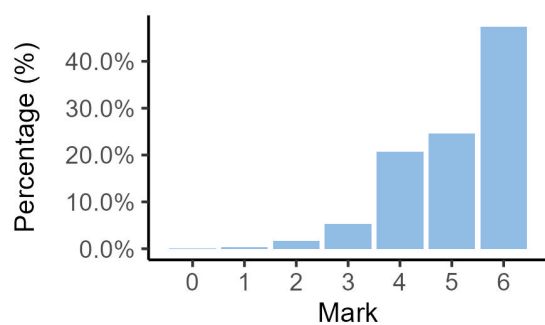
IA3 Criterion: Analysis and interpretation
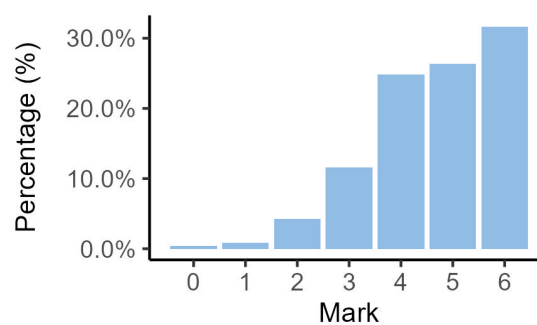
IA3 Criterion: Conclusion and evaluation
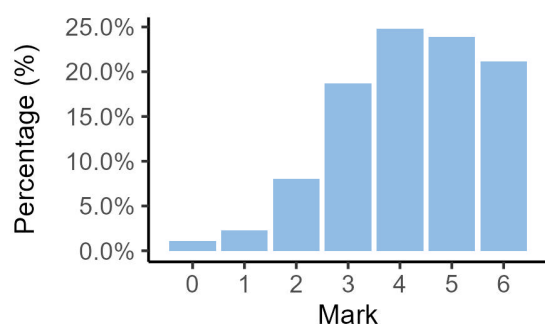
IA3 Criterion: Communication
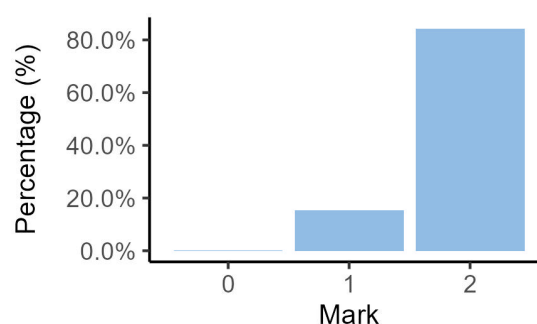
External assessment (EA) marks
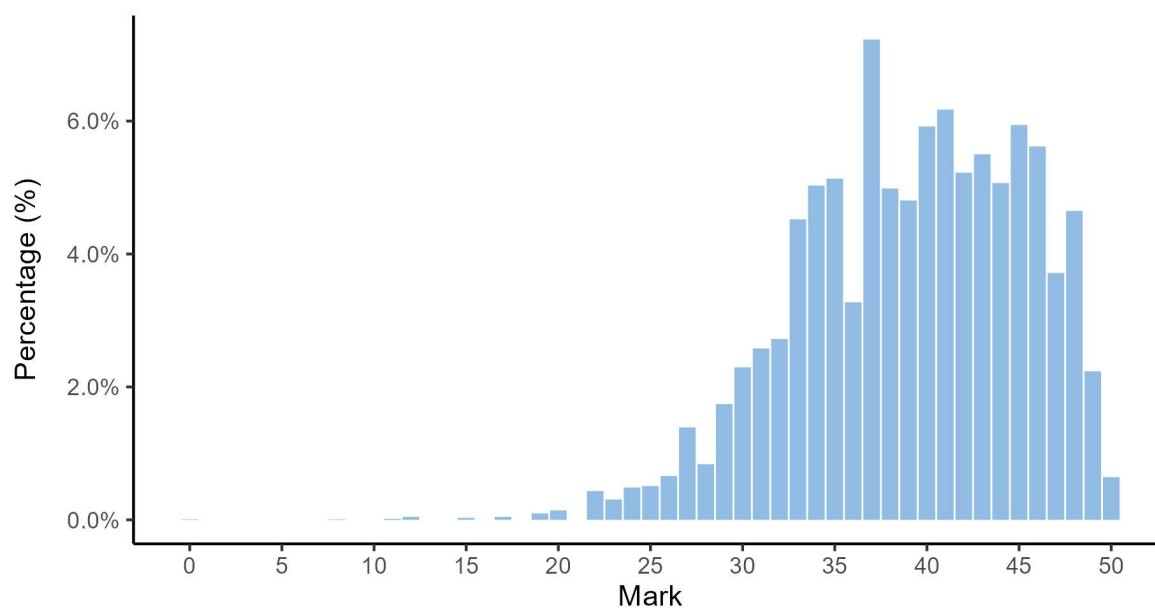
Final subject results

Final marks for IA and EA
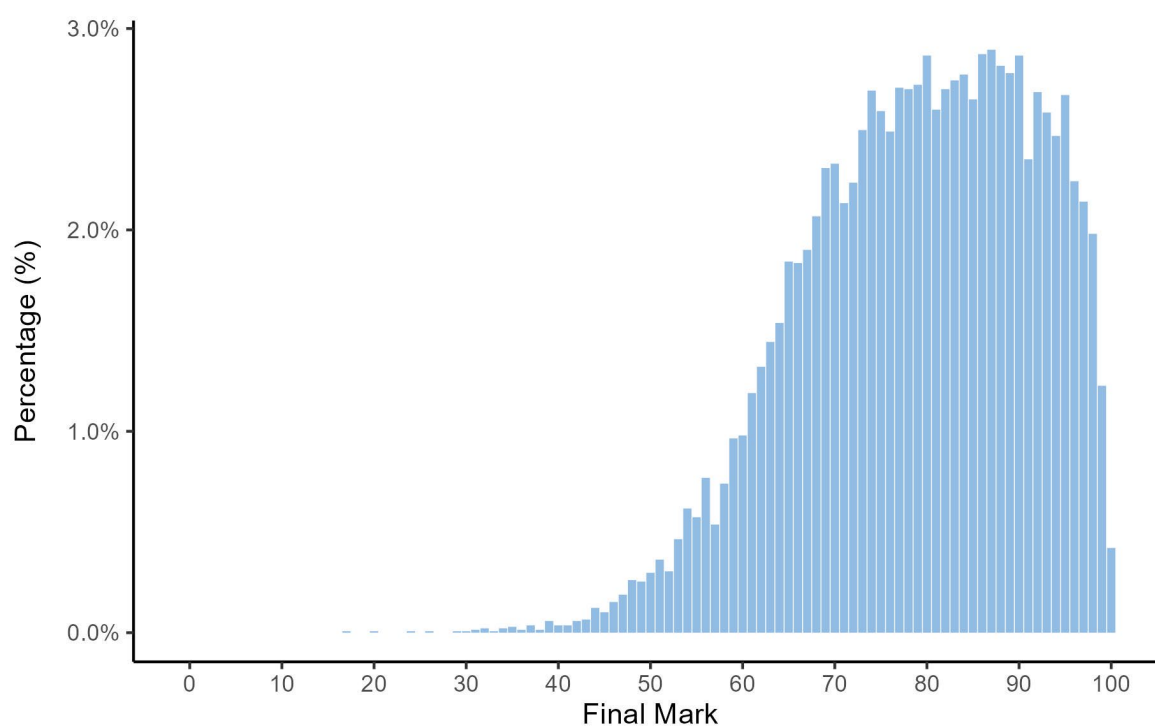
Grade boundaries

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	86–70	69–50	49–20	19–0

Distribution of standards

The number of students who achieved each standard across the state is as follows.

Standard	A	B	C	D	E
Number of students	4,431	6,111	3,041	211	1

Internal assessment

The following 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 v6.0*, Section 9.5.

Percentage of instruments endorsed in Application 1

Instruments submitted	IA1	IA2	IA3
Total number of instruments	447	447	447
Percentage endorsed in Application 1	52	94	88

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 v6.0*, Section 9.6.

The following table includes the percentage agreement between the provisional marks and confirmed marks by assessment instrument. The Assessment decisions section of this report 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	446	3,647	0	100.00
2	447	3,658	67	86.16
3	447	3,651	130	83.89

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	119
Authentication	0
Authenticity	1
Item construction	20
Scope and scale	71

Effective practices

Validity priorities were effectively demonstrated in assessment instruments that:

- structured questions to clearly direct students to use the dataset, e.g. if additional information such as a *p*-value was provided in a question, students were still required to engage with information in the dataset to develop a response

- limited repetition of skills by ensuring that the same calculation or process was not repeated across multiple questions, e.g. where students were required to compare the biodiversity of two sites using Simpson's diversity index (SDI), one or more SDI values were provided in the dataset

- matched the number of marks allocated for each question to the required cognitions, e.g. 2 marks for *infer* items (1 mark for inference, 1 mark for reasoning).

Practices to strengthen

It is recommended that assessment instruments:

- appropriately align questions to assessment objectives based on the nature of the response, not just the cognitive verb, e.g. Questions requiring classification of an ecosystem using field data align to Objective 4 (Interpret evidence), as they require a conclusion to be drawn based on analysis of the dataset, rather than the identification of a trend, pattern, relationship, limitation or uncertainty (see Syllabus section 4.5.1: Mark allocations).

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	13
Language	80
Layout	23
Transparency	65

Effective practices

Accessibility priorities were effectively demonstrated in assessment instruments that:

- limited the amount of theory and background information provided with the datasets

- provided clear and concise instructions directing students to use the data in their responses, e.g. 'Justify your response using the data'

- used diagrams or sketches that were clear and unambiguous. This was particularly important for datasets involving diagrams of transects/quadrats, where responses required percentage cover and height of tallest strata to be determined from the diagram.

Practices to strengthen

It is recommended that assessment instruments:

- use cognitive verbs that align with the objectives being assessed to clearly cue the expected responses identified in the marking scheme, e.g. *draw a conclusion*, *infer* or *predict* for Objective 4 (Interpret evidence) items (see Syllabus section 4.5.1: Mark allocations)

- are checked for clerical errors such as grammar, punctuation and spelling errors

- are checked for appropriate formatting, e.g. by using page breaks to ensure that questions, headings and datasets are easily accessible.

Assessment decisions

Reliability

Reliability is a judgment about the measurements of assessment. It 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	0	0	0

Effective practices

Accuracy and consistency of the application of the ISMG for this IA was most effective when:

- the marking scheme clearly showed what each mark was awarded for, including where follow-through error was allowed

- student responses were annotated to show how marks were awarded in accordance with the marking scheme, e.g. by including a tick for each aspect of the response matched to the marking scheme and writing 'FTE' when follow-through error was applied

- alternative responses were captured in the marking scheme and annotated to show how marks were allocated.

Practices to strengthen

To further ensure accuracy and consistency of the application of the ISMG for this IA, it is recommended that:

- marking schemes are updated prior to confirmation to ensure errors are corrected and alternative student responses are accounted for

- follow-through error is only awarded when the cognition or concept being assessed is impacted by an error in a previous step

- marks are correctly totalled, percentages are accurately determined, and cut-offs from the ISMG are correctly applied to determine provisional marks, e.g. 14/20 = 70%, which is >60%, so 7 should be awarded.

Samples

The following excerpt demonstrates the use of annotations to indicate where the student response matches the valued features of the expected response to an Objective 3 (Analyse evidence) item requiring students to contrast energy transfer.

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

Additional advice

- Schools should review and refine their marking schemes to ensure unexpected and alternative student responses are accounted for. Any amendments must be evident in the marking scheme that is uploaded for confirmation.

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	3
Authentication	4
Authenticity	1
Item construction	11
Scope and scale	0

Effective practices

Validity priorities were effectively demonstrated in assessment instruments that:

- included a task description that matched the task specifications in Syllabus section 4.5.2

- included scaffolding that was consistent with the advice provided in the *QCE and QCIA policy and procedures handbook v6.0*, Section 8.2.3

- avoided repetition of information in different sections of the task.

Practices to strengthen

It is recommended that assessment instruments:

- contain consistent conditions across the task, e.g. If a draft is mentioned in the checkpoints, it should also be identified as an authentication strategy; if group work is indicated in the task specifications, strategies to authenticate student work should address group work

- provide appropriate checkpoints, consistent with the advice in *QCE and QCIA policy and procedures handbook v6.0*, Section 8.

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	4
Layout	0
Transparency	8

Effective practices

Accessibility priorities were effectively demonstrated in assessment instruments that:

- provided clear instructions aligned to the assessment specifications in Syllabus section 4.5.2

- included asterisks (*) in the task description to identify which aspects could be completed in groups, and a statement explaining the meaning of the asterisks

- were free of clerical errors and used appropriate language, grammar and punctuation

- were appropriately formatted, e.g. by including each checkpoint as a separate bullet point.

Practices to strengthen

There were no significant issues identified for improvement.

Assessment decisions

Reliability

Reliability is a judgment about the measurements of assessment. It 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	93.06	6.04	0.67	0.22
2	Analysis of evidence	93.96	5.59	0.45	0.00
3	Interpretation and evaluation	93.74	5.59	0.67	0.00
4	Communication	99.55	0.00	0.45	0.00

Effective practices

Accuracy and consistency of the application of the ISMG for this IA was most effective when:

- in 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, e.g.

    - line graphs with error bars to show trends

    - scatterplots with correlation coefficients to identify relationships

    - bar graphs with error bars and Student's t-tests to make comparisons

    - standard deviation and/or standard error to identify uncertainty

  - *thorough* identification of trends, patterns or relationships provided meaningful insights from the data that were directly relevant to answering the research question

  - *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

- in the Communication criterion

  - understanding of the subject matter and experimental findings were *fluently* and *concisely* conveyed through accurate use of

    - discipline-specific language

    - symbols, units and prefixes

    - indicators of measurement uncertainty, e.g. standard error

    - tables, graphs and diagrams

  - findings were communicated using appropriate genre conventions, e.g. for scientific reports

    - tables, graphs and diagrams were appropriately titled/captioned and labelled

    - statistical measures represented by error bars were clearly stated in the graph title or caption

    - findings were presented in appropriate sections

  - *appropriate* referencing conventions acknowledged sources through the consistent use of an accepted referencing methodology, e.g. APA or Harvard.

Practices to strengthen

To further ensure accuracy and consistency of the application of the ISMG for this IA, it is recommended that:

- in the Research and planning criterion

  - a *considered* rationale demonstrates understanding of Unit 3 concepts by establishing a logical basis for the experiment and explaining the relevance of the independent and dependent variables

  - a *relevant* research question allows students to investigate biodiversity or ecosystem dynamics, e.g. when abiotic factors are investigated, it should be in the context of their effects on biodiversity or ecosystem dynamics

  - *justified* modifications reference the original methodology and explain how each modification will improve the reliability or validity of the experiment

- in the Conclusion and evaluation criterion
  - *logically derived* improvements address aspects of the experiment identified as affecting reliability, e.g. using different sampling techniques to reduce standard error
  - *logically derived* extensions address aspects of the experiment identified as affecting validity, e.g. including different lichen species in an experiment investigating the effect of bark type on lichen abundance.

Samples

The following excerpts demonstrate a considered rationale, appropriate use of historical evidence, justified modifications to the methodology, and a justified conclusion linked to the research question.

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

Excerpt 1

Rationale

Ecology is the study of natural ecosystems which are formed through the interactions between living organisms and the surrounding environment (National Geographic, 2024). In South-East Queensland sclerophyllous forests are commonly formed through the interactions between native sclerophyllous genera such as *Eucalyptus, Acacia,* and *Banksia* in a sub-tropical climate (Queensland Government, 2014). As these ecosystems are highly prevalent in the local area and have therefore been selected to perform this experiment.

Ecosystems are dynamic and change in response to environmental disruptions and changes of abiotic and biotic factors favouring the presence of specific organisms in accordance with the competitive exclusion principle (Khan Academy, 2024). This principle identifies that two species cannot coexist in the same ecological niche indefinitely pushing one species to thrive over the other (Britannica, n.d.). Ecological succession is an ecological process which describes how the structure of a biological community develops and changes over time and is measurable through the abundance of pioneer species versus intermediate species versus climax species. Primary succession occurs when species presence develop overtime in an once barren or lifeless location (Witynski, n.d.). Conversely, secondary succession occurs when a major disturbance changes species presence over time (Openstax, n.d.). White's Hill Reserve is a local dry sclerophyll forests subjected to semi regular disturbances in the form of planned burns (Brisbane City Council, 2021). These planned burns are likely to initiate secondary succession in this ecosystem and will therefore be investigated.

Data of species abundance in White's Hill Reserve was provided from previous years (Cavendish Road State High School, 2021), which was used to identify an initial relationship between the abundance of *Eucalyptus* and *Acacia complanta*. *Eucalyptus* is a climax species, thereby taking longer to grow becoming dominant in an ecosystem at the end of the ecological succession process (Otway Greening, n.d.). *Acacia complanta* is a pioneer species, which initially inhabits the ecosystem following a disturbance (NSW Government, 2021). There is a relationship of amensalism between *Eucalyptus* and *Acacia complanta*, whereby as time progresses since the disturbance Eucalyptus grow larger inhibiting Acacia complanta growth/survival due to significant canopy coverage. This results in the relationship of succession between the species, whereby the abundance of each change over time following the disturbance.

The provided research showed initial evidence that increased eucalyptus abundance correlated to decreased *Acacia complanta* abundance. This should be further investigated to consolidate if a relationship representative of ecological succession is present, thus the following research question (RQ) was formulated:

What is the effect of increased abundance of eucalyptus species on *Acacia complanta* abundance in a dry sclerophyll forest recently following a planned burn?

Excerpt 2

Modifications to method

The method followed in this investigation was as described in the TFEEC Field Trip Manual (2023) with the following modifications:

- Systematic sampling within two sites, under consistent conditions between all trials of equal distance from path and creek to minimise variation caused by human impact and soil moisture, improving reliability of results.
- Two areas were selected in accordance with online planned burns record of White's Hill Reserve to identify an area recently burned, 2021, and an area with no record of burning, to allow comparison to support or refute the impact of ecological succession increasing validity.
- Only species relevant to the RQ, *Eucalyptus species* and *Acacia complanta*, were recorded to improve validity of results.
- *Eucalyptus* species were not segregated as they all occupy the same ecological niche making to easier to recognise relationship between the climax and pioneer species.
- Wattle species were segregated creating a more specific investigation and account for potential unevenness between the common species which could skew trends, increasing reliability and validity of results.
- Canopy coverage is the only abiotic factor to be measured to eliminate abiotic factors and data irrelevant to the RQ, increasing validity of results.
- Performing replicate trials decreases impact of random errors whilst increasing sample population to improve reliability of results.

Excerpt 3

The results collected in this experiment conclude that, in accordance with ecological succession, increased abundance of *eucalyptus species* (correspondingly increasing canopy cover) adversely affects the abundance of *Acacia complanta* in a dry sclerophyll forest post fire disturbance. This was supported by the statistically significant difference in *Acacia complanta* abundance, decreasing from 22.25 to 4 between conditions($p=0.000061$). This correlates to the statistical significance between the *eucalyptus* abundance in the burned condition, 4, and unburned condition, 9.5 ($p=0.02478$) and increased canopy cover from 35.08% (burned) to 89.98% (unburned) represented in Figure 1 and 2. This supports the theory defined in the rationale, where the pioneer species abundance is decreased as growth is inhibited by increased abundance of the climax species in correlation with canopy cover.

The validity and reliability of results is impacted by the limited number of quadrats within each condition sampled, with identified sources of error implicating lowered precision and accuracy of results. Despite this, results provide sufficient evidence which can be extrapolated to make conclusions regarding the RQ. The proposed improvements and extensions should be adapted, to offer broader conclusions surrounding ecological successions impact on species abundance in dry sclerophyll forest ecosystems.

The following excerpts demonstrate a specific and relevant research question and considered management of risks and ethical or environmental issues specific to the research question.

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

Excerpt 1

Research Question:

Is there a significant difference between the abundance of the Planaxis sulcatus present in the upper, middle, and lower littoral zones, of Shelly beach?

Excerpt 2

Risk Assessment

Risk	Risk management
Algae on the rock platform causes slip hazards	Closed in footwear with grip was always worn. Areas of the rocky platform that were covered in algae were avoided, to minimise the slipping hazard.
Harmful/poisonous organisms	Only Planaxis sulcatus were investigated, which posed no risk to humans. Samplers were educated on the risks of the other species present.
Hazards from tides and wave action.	Tide times were researched beforehand. Initially the LLZ was submerged in water, so the other zones were sampled until it was safe to enter the LLZ. Researchers avoided having their backs facing the waves.
Environmental impacts	The rocky platform was left as undisturbed as possible. No abiotic features were altered or moved. Disturbances to organisms were minimised.
Ethical	The experiment posed ethical risks as living organisms were involved, but to minimise this the organisms were not handled or displaced. This meant none were intentionally harmed. Quadrats were carefully placed down to decrease the impact on the ecosystem.

The following excerpts demonstrate thorough identification of relevant trends, patterns and relationships; thorough and appropriate identification of the uncertainty and limitations of evidence and suggested improvements and extensions that are logically derived from the analysis of evidence. The research question focused on the impact of _Acacias_ on the seedling regrowth of other species through disruption of typical light intensities at ground level.

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

Excerpt 1

Table 4 displays a high proportional abundance of acacias within the fire-affected community, with a mean number of 3.83 acacias per quadrat. This is 3.33 higher than the unaffected community's mean of 0.5, indicating early-stage secondary succession within the affected community, as this difference suggests pioneer species are still the dominant species. This dominance denotes low diversity, as higher abundances of a dominant species cause fewer resources for concomitant species, thus lowering species richness (VV Akatov et al, 2020). This is supported by the low number of species in the affected community. Ranging from 2 to 5, the mean number of species is 3.25. This is 2.33 lower than the unaffected community, which peaks at 8 different species – 1.6x the affected community's maximum number of species. Thereby, there is lower species richness and diversity in the affected side. Light intensity is also significantly lower. The fire-affected community has an average light intensity of 92.42*100LUX, ranging from 37.33*100LUX to 237.78*100LUX, whereas the unaffected community ranges from 96.49*100LUX to 1085*100LUX, with a mean approximately 8.17x higher, at 755.19*100LUX – a difference of 662.17*100LUX. The correlation between higher light intensities and higher species diversity suggests that with lower light availability at ground level caused by the dominating regrowth of acacias, seedling regrowth of other species is reduced. This corroborates with a 2023 study, where "seedling vitality index and survival percentage decreased with decreasing light intensity", with the opposite found true for reversed conditions (Hang Chen et al, 2023).

Error bars comprised from standard error calculations

Figure 2 — Average Light Intensity at Ground Level

Figure 3 — Average Number of Plant Species Present
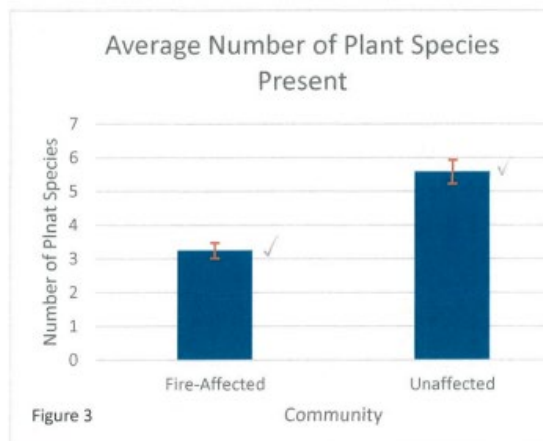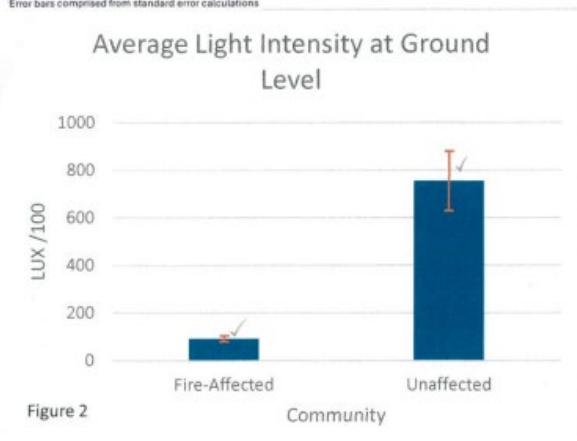
Figure 2 demonstrates the difference in light intensity between communities, and Figure 3 the number of plant species present. The fire-affected community displays a significantly lower light intensity at ground level than the unaffected community, with a light intensity of approximately 96*100LUX. The unaffected community has a light intensity approximately 650*100LUX higher, corroborating with Table 4's findings. Similarly, the fire-affected community has a mean number of plant species per quadrat of approximately 3.2 – around 2.4 lower than the unaffected community at around 5.6. This demonstrates the correlation between light intensity and number of species, suggesting that in this environment, an increase in light intensity increases the number of plant species, further supporting the research question and previous interpretation in Table 4 that seedling regrowth is reduced with lower light intensities.

Figure 4

Plant Coverage at Ground Level Within Fire-Affected Community

■ Grasses ■ Bare Ground ■ Acacias ■ Other Shrubs
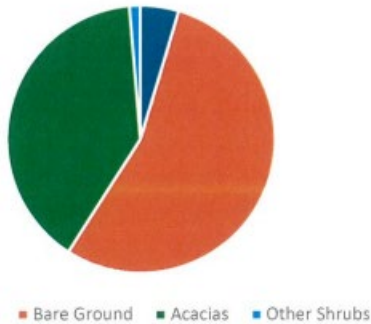
Figure 5

Plant Coverage at Ground Level Within Unaffected Community

■ Grasses ■ Bare Ground ■ Acacias ■ Other Shrubs
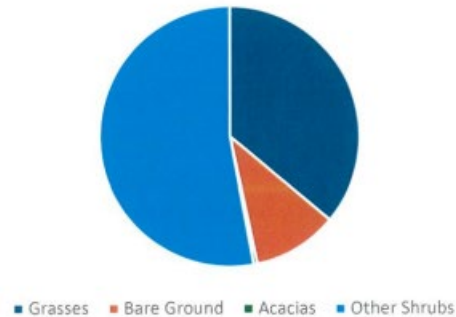
As per Figure 4, the fire-affected community has a percentage cover of approximately 54% bare ground, and 40% acacias. There is minimal regrowth (5%) of grasses, and only 1% of cover is other shrubs. Figure 5, however, displays that the unaffected community has near-reversed statistics. Other shrubs compose 53% of the community, and grasses 36%. Due to this, bare ground is reduced to 11% – 43% less than the affected community – and acacias are almost not present. The lack of pioneer species suggests that succession from an earlier event was successful, corroborated by the higher numbers of different species and thus diversity in Table 4. Reduced light availability at ground level correlates to large amounts of bare ground under the acacia's canopy, and minimal regrowth of other species, supported by Table 4 and Figures 2 and 3. Thereby, it is likely that acacias have negatively influenced seedling regrowth of other plant species by decreasing typical light intensities.

However, there are potential uncertainties within the data. According to Table 4, light intensity measurements within the fire-affected community have a standard deviation of ±40.33LUX, and a range of 192.05. The unaffected community has a deviation of ±755.19LUX, which is 714.86 higher than the fire-affected, and range of 1378.47, which is 1186.42 higher. This indicates variance and inconsistencies, but does not denote error, as the method was refined and followed. Deviations are instead likely due to natural variation – topography, soil type, species composition and thereby canopy heights and densities. The deviation acts as a measure of this diversity and variation, and may imply that that the fire-affected side, with less deviation, has more homogeneity in its canopy height and species composition, and thus a lower diversity. This also explains the standard deviation in number of acacias and number of species present – the unaffected side, as a climax community, should have more species (LaRoche, 2023) and variation, and natural variation dictates a near-impossibility of numbers in either community being equal across each quadrat. Thus, the data is still statistically significant, which is again supported by error-bars that do not overlap, suggesting variance in community samples are due to differences in species composition. Therefore, due to multiple ecological factors, there are high site standard deviations in plant distributions and densities, but this does not decrease reliability.

Excerpt 2

Despite standardising the data, the values used to standardise were measured only once per sampling day. Across the sampling hour, cloud cover and sun position changed, impacting light intensity and thus validity. These values for standardising were also measured at inconsistent times – within a 60-minute timeframe; sun position changes approximately 15° in 60-minutes (Whitt, 2023), so the inconsistencies cause inaccuracies, decreasing validity and reliability.

The topography between and within the communities also differed. Rock and variance in soils/soil depths impacts how, where and which plants grow (Sameh K. Abd-Elmabod, 2017)(EZYPlant, 2022). This variance between communities reduces comparability, thus reducing reliability and validity.

The *Digital Light Meter LX1010B* has an error margin of $\pm5\%$ (SoundStore Australia, 2024); each light reading could be inaccurate, and has not been standardised to account for this, decreasing reliability. For example, $\pm5\%$ of the fire-affected community's mean light intensity (92.42LUX) implies possible inaccuracies of up to ±4.621, meaning possible increases in standard deviation, error and range.

Sampling techniques were biased for ease of access, safety and the ethical requirement of leaving the environment undamaged – quadrats were not placed with complete randomness, particularly in the fire-affected side, as this was considerably denser. This reduces reliability, may not provide an accurate representation of the communities, and may not provide an accurate estimation of relationships between how acacias have impacted light intensity and thereby plant species regrowth.

Data for percentage cover was gathered by eye with little knowledge of plant species; lack of research means some species may have been incorrectly documented as different/equal to another, and the density of growth may have obscured some plants. Therefore, inaccurate values may have been provided, decreasing validity.

Suggested Improvements

To improve the experiment:

- Standard light should be taken each time light intensity is measured. This would reduce inaccuracies in standardisation, thus improving validity and reliability of results.
- Improved technology would also improve reliability. The *Lightmeter (LUX) with Detachable & Rotatable Sensor – IC-CENTER530* has a 3% +5 accuracy (Synotronics, 2020), reducing uncertainty and thereby increasing reliability and validity.
- Quadrat positions should be chosen with complete randomness. To ensure this, the survey area should be divided into 1m² spaces (quadrat-sized) and numbered accordingly, and a random number generator used to choose associated x- and y-coordinates. This eliminates bias, increasing reliability.
- More research should be done on Murray's Bay plant species to ensure each are correctly identified as different or equal to another, increasing validity and reliability by reducing human error.
- An ecologist should peer-review the methodology to increase precision in data-collection methods and reliability of results by removing methods causing inaccuracies.

Extensions

To extend the experiment:

- Refinement – sampling the numbers of each species in a quadrat would allow for SDI calculations. SDI better indicates biodiversity within a community taking abundance into account (Barcelona Field Studies Centre, 2023).✓
- Extension – topography significantly influences soil development (Plant and Soil Sciences eLibrary, 2024), as does soil with plant species and growth (Sameh K. Abd-Elmabod, 2017). Measuring topography may help account for natural variation and uncertainty in the data, as will measuring soil pH and moisture. ✓

The following excerpt demonstrates a justified discussion of the reliability and validity of the experimental process. The research question focused on determining how the bark type of *Harpullia pendula* and *Eucalyptus sideroxylon* trees affect the percentage cover of crustose lichen at a height of 1.5 metres.

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

Effecting Reliability

Table 1 displays through the RSD values of 32.0263% and 30.979%, that both species contain high uncertainty, thus indicating that there is significant variability in tree samples. These reduces the reliability that the identified trend of increased lichen growth on *Harpullia pendula* trees would occur if the experiment was repeated. Similarly, the limited number of trees surveyed undermines the consistency of these results as due to inherent biological variation, lichen growth varies significantly per tree. Selecting only five trees does not adequately represent the variability within the tree population and thus the reliability of these results is diminished. Additionally, lichen percentage cover was determined through estimating the amount of squares covered when a clear grid was held against the tree. As seen in Table 2, squares were often estimated to be less than a full square, which cannot be accurately determined by sight. This would contribute to the imprecision of measurements and further increase the variability in the data as shown by the high RSD values.

Effecting Validity

When determining percentage cover using clear grids, two different people completed this by eye estimate, which significantly decreases the validity of the experimental process as differing subjectivity and inaccuracy is inbuilt into the method. Additionally, Appendix 1 displays that a larger abundance of lichen was observed to occur at higher heights on the *Eucalyptus sideroxylon* trees than 1.5m, indicating that height may impact lichen growth. An investigation into tree height on the growth of terricolous lichen headed by Professor Wegryzn at Jageillon University, found that lichen growth will be found in various heights upon a tree depending on where favourable habitat conditions were found (Wegrzyn et al, 2021). Therefore, there is reasonable belief that tree height may influence lichen growth and thus diminishes the validity of the current methodology, as it does not account for all impactful variables. Furthermore, rationale indicated that crustose lichen prefers' a high intensity of sunlight to photosynthesise and when comparing Appendix 1 to 2, it's clear that *Harpullia pendula* trees are exposed to greater degrees of sunlight at the same time of day. These factors further decrease the validity of the experiment as confounding variables could've possibly skewed results as it cannot be accurately determined whether bark type was solely responsible for the differing percentage cover of lichen.

Additional advice

- Appendixes should only include supplementary material that will not be directly used as evidence when marking the response (*QCE and QCIA policy and procedures handbook v6.0*, Section 8.2.6). If raw data is included in an appendix, there must be evidence of collection of sufficient and relevant raw data in other areas of the response, e.g. methodology, sample

calculations and data presentation. Evidence of *considered* management of risks, ethical and environmental issues should be included in the body of the report.

- Student experiments using databases or historical evidence as a source of data should indicate how students engaged with the database and how they refined, redirected or extended the investigation through the collection of primary data. Using historical data as the only source of evidence is not sufficient for a student experiment, which requires students to research a question or hypothesis through collection, analysis and synthesis of primary data

- Responses should be appropriately annotated to show when and how authentication strategies have been applied to support judgments related to word count

- The marked ISMGs should clearly indicate the characteristics evident in the student response and the mark awarded for each criterion. Schools should consider evidence throughout the entire response when deciding which characteristics the evidence best matches.

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	28
Authentication	8
Authenticity	1
Item construction	6
Scope and scale	9

Effective practices

Validity priorities were effectively demonstrated in assessment instruments that:

- contained simple and direct claims that linked to only one context, and avoided 'and/or' options, e.g. gene therapy affects the severity of disease
- clearly and accurately identified which topics were being assessed, e.g. by showing consistency between the conditions section of the task and the subject matter identified in the claims.

Practices to strengthen

It is recommended that assessment instruments:

- contain claims that directly cue students to analyse and interpret information relating to Unit 4 subject matter, e.g. avoid claims that have potential for redirection into ethical issues that may limit a students' ability to address all assessment objectives.

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	1
Language	6
Layout	1
Transparency	4

Effective practices

Accessibility priorities were effectively demonstrated in assessment instruments that:

- were formatted to provide task information in each section consistent with syllabus descriptions

- were free of spelling, punctuation and grammatical errors.

Practices to strengthen

There were no significant issues identified for improvement.

Assessment decisions

Reliability

Reliability is a judgment about the measurements of assessment. It 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	93.51	4.70	1.57	0.22
2	Analysis and interpretation	93.06	5.82	1.12	0.00
3	Conclusion and evaluation	89.71	9.84	0.45	0.00
4	Communication	99.55	0.22	0.22	0.00

Effective practices

Accuracy and consistency of the application of the ISMG for this IA was most effective when:

- in the Analysis and interpretation criterion

    – evidence was presented in tables and graphs that allowed for *thorough* identification of trends, patterns and relationships directly related to the research question

    – *sufficient* secondary evidence was included to validly address all aspects of the research question, e.g. multiple sources of evidence allowed limitations of one source to be addressed

– *thorough* and *appropriate* identification of limitations was specific to the research question and identified how or why each limitation made the evidence less effective, e.g. by considering which aspect/s of the research question each piece of evidence addressed.

Practices to strengthen

To further ensure accuracy and consistency of the application of the ISMG for this IA, it is recommended that:

- in the Research and planning criterion

  – a *considered* rationale demonstrates informed application of Unit 4 concepts to clearly show how the research question was developed from the claim

  – *specific* and *relevant* research questions are clearly defined, link to the claim and require investigation of Unit 4 concepts, e.g. research questions relating to the impacts of climate change should identify a specific selection pressure and phenotype to ensure the investigation is directed towards Unit 4 topics

- in the Conclusion and evaluation criterion

  – *insightful* discussion of the quality of evidence considers how well the evidence answers the research question and the extent to which limitations identified in the analysis of evidence influence the validity of the conclusion

  – *justified* conclusions are backed by evidence, specific to the research question, and based on scientific arguments developed throughout the response

  – *logically derived* improvements and extensions focus on ways the research investigation could be refined or extended to obtain more valid evidence applicable to the claim.

Samples

The following excerpts demonstrate the connections between a considered rationale; a specific and relevant research question; thorough identification of relevant trends, patterns or relationships; thorough and appropriate identification of limitations of evidence and extrapolation of credible findings of the research to the claim. The student was responding to the claim 'GM crops are more efficient to grow'.

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

Excerpt 1

Rationale

Species domestication has been characterised by targeted breeding to develop more advantageous phenotypic characteristics, human-determined selection which has caused domesticated species' gradual genetic divergence from their wild ancestors (National Research Council, 2004). Crucial agricultural innovations and scientific discoveries since the Industrial Revolution have cumulated in CRISPR-Cas9 technology, 'genetic scissors' which modify organisms' genomes in scientific experimentation; to treat and prevent genetic diseases; and to manipulate agricultural crops' characteristics (Gostimskaya, 2022). Compared to gradual genomic changes of early domesticated species, achieved over millennia, this active modification means new crops can be developed rapidly. Although ethical and environmental concerns remain contentious, genetically modified (GMO) plant crops now constitute a significant proportion of the global market.

Glycine soja is the wild ancestor of domestic soybean, *Glycine max*. *G. max* is an important agricultural crop, grown predominantly as livestock fodder. With a global sector worth AUD 173.1 billion, 353 million tonnes were produced in 2020 from 126 million hectares globally (Voora, et al., 2024). A significant proportion of this revenue comes from *G. max* cultivars genetically modified using transgenic technologies, an agricultural process used to improve crop efficiency by introducing genetic information from other organisms into crop species' genomes (Kollias, 1998). Most transgenic soybeans cultivated worldwide are herbicide-tolerant (HT), metabolising glyphosate following the insertion of genetic information from soil bacterium *Agrobacterium tumefaciens* into soybean genome (Seixas, et al., 2022). HT crops offer increased effective weed control options; are associated with lower production costs, particularly on herbicides; and may exhibit greater seed yield than non-GMO cultivars (U.S. Department of Agriculture, 2023). Given the importance of crop efficiency, specific genetic modification has been conducted in studies to maximise seed yield in tonnes per hectare. Research by De Souza, for instance, introduced the VPZ genetic construct from *Arabidopsis thaliana* into *G. max*'s genome to accelerate photoprotection recovery, an energy-intensive process used under UV light to reduce photosynthesis and protect plant tissue (2022).

In recent decades, concern about global environmental impacts and sustainability of genetic modification's reduction of genetic diversity has grown. Genetic diversity measures variation within a species, and supports ecological systems' abiotic and biotic interactions, providing crucial resilience and stability by enabling species to adapt to rapid environmental changes (Hoban, et al., 2022). Amid a climate crisis, and its global agricultural and economic impacts, it is of great importance to analyse and evaluate whether economic effects of genetically modifying *G. max* outweigh environmental consequences (Voora, et al., 2024). Thus, this investigation will conduct a statistical analysis of three studies comparing GMO *G. max* cultivars with non-GMO *G. max* or *G. soja* in terms of seed yield.

Research Question

Does transgenic *Glycine max* improve commercial agricultural productivity compared with non-transgenic *Glycine max* and *Glycine soja* in terms of seed yield?

Excerpt 2

Figure 2 shows *G. soja* was less productive than *G. max* cultivars. While all eight *G. max* cultivars generated a higher yield than *G. soja*, this difference was marginal for two cultivars. Overall, three transgenic cultivars demonstrated error bar overlap and no statistical difference with *G. soja*; two demonstrated a statistical difference with a *p*-value <0.1; and three demonstrated a significant statistical difference <0.05 (Figure 2). While non-GMO soybeans were not significantly less productive than transgenic variants, data nevertheless demonstrates cultivating specific variants of transgenic soybeans which are genetically modified to accelerate recovery from photoprotection (such as ND-18-34A cultivar) is conducive to yield optimisation. The better performance of GMO soybeans is likely due to saving the high energy output (>11% of carbon assimilation) of photoprotection recovery processes, which could instead be used for growth (De Souza, et al., 2022).

Statistically significant *p*-values and absent error bar overlap for three cultivars strengthened observed trend reliability; while all cultivars were farmed on an agricultural scale, ensuring collected data accurately presented performance of crops and findings were valid and relevant in investigating more efficient agricultural pathways. Nevertheless, several limitations were observed. Only one WT (non-commercial *G. soja*) cultivar was compared with eight GMO commercial cultivars, a sample size which is too small to conclusively deem trends reliable. Meanwhile, the study's failure to include either non-GMO or GMO HT commercial cultivars reduces its relevance. Furthermore, collected data only covers one year, a limited amount of research which means the performance and sustainability of developed cultivars under variable environmental conditions remains unclear, reducing the study's relevance and reliability of observed trends.

Excerpt 3

Ainsworth demonstrated GMO HT soybeans were significantly greater seed yield than both non-commercial and commercial non-GMO cultivars (et al., 2010). De Souza found soybeans genetically modified to accelerate photoprotection recovery produced higher seed yield than non-GMO, 'wild-type' soybeans (et al., 2022). Finally, Brookes and Barfoot showed that commercially cultivating GMO soybeans resulted in cost savings in all 10 countries, and increased seed yield in eight (et al., 2018). Thus, in answer to the research question, this investigation can conclude that genetically modifying soybeans increases yield.

Collected evidence supports the claim that genetic modification increases crop productivity. However – given only soybeans genetically modified to improve crop seed yield were investigated – the conclusions cannot be extrapolated to the claim in its entirety to assume that observed trends are evident for all crops; all genetic modification; and all crop productivity measures. To provide a more insightful and relevant answer to the claim through source comparability, the investigation could be improved by ensuring that data compares the same transgenic cultivars against the same parameters. Furthermore, only data covering several years should be considered, ensuring interpretations validly consider long-term crop performance.

This could further be extended by conducting studies on a greater variety of GMO crops and their non-GMO counterparts – such as cotton, alfalfa and corn – to determine whether the same trends are evident. Moreover, to provide a more balanced depiction of GMO crops and their applications, the investigation should be extended to include more measures of crop productivity, such as disease resistance and biochemical properties. Finally, information should be consistently collected over several consecutive years across crops grown in a variety of countries to determine the effect of environmental conditions, thereby ensuring relevance and reliability of collected data in lieu of a rapidly changing climate.

The following excerpts demonstrate the identification of sufficient and relevant evidence.

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

Excerpt 1

Research Question

How effective is voretigene neparvovec-rzyl gene therapy in improving reduced retinal light sensitivity caused by RPE65-associated retinal dystrophy?

Excerpt 2

Pre-treatment, patients had a recorded FST sensitivity of $1.3d.s/m^2$, before significantly increasing to $3.23d.s/m^2$ 30 days post-treatment. Over the year, patients' sensitivity remained relatively stable, ranging from $3.18d.s/m^2$-$3.48d.s/m^2$. There is a slight decrease of $0.18d.s/m^2$ from day 180 ($3.48d.s/m^2$) to 1 year ($3.30d.s/m^2$). This may suggest that sensitivity begins to decrease again after one year, or this have may have simply been a slight variation in sensitivity. Conversely, control patients' sensitivity remains relatively constant, with slight gradual decrease over the course of the year (corroborating research regarding RPE-RD's degenerative nature). The data only records patients' sensitivity after one year, limiting the data's ability to demonstrate long-term effects of Luxturna. The disproportionate sample size (with 20 intervention patients and only nine control) may cause slightly skewed results and fail to adequately account for variability in the control group. Thus, this source establishes that Luxturna causes long-term increases white light sensitivity, rather than just temporary treatment, improving their vision in low-light conditions and peripheral vision.

Excerpt 3

Both treated and untreated patients' QALYs followed a similar trend, with both starting with the same QALY (between 0.80-0.90), before gradually declining to 0 around 100-110 years (indicating death). However, there is a clear relationship between the stage of intervention and effectiveness of treatment, with early-stage treatment increasing Luxturna's effectiveness. Evidently, early-stage intervention patients had an overall average increase of +14.3 QALY, with this value decreasing to +6.22 for mid-stage intervention, and +1.48 for late-stage. At 60 years, patients with earlier intervention had higher QALYs (early-stage:0.73, mid-stage:0.68, late-stage:0.60). Depicted in all graphs, Luxturna causes immediate improvement in vision (and thus QALY), before gradual decrease (due to age), with treated patients having consistently higher QALYs until death. However, a limitation of the data is that it defines 'early-stage' as intervention at 20 years old, failing to explore Luxturna's effectiveness on paediatric cases.

Considering RPE-RD is a degenerative disease, this data corroborates other sources and demonstrates Luxturna's immediate effectiveness in delaying retinal degeneration (dissimilar from Source 1 which showed immediate FST sensitivity improvement). This source demonstrates a more holistic approach towards RPE-RD treatment, focussing on QALY and how treatment is effective in elevating overall life quality, rather than whether or not it cures the disease. Furthermore, it explores how critical early intervention is in increasing Luxturna's effectiveness.

Excerpt 4

Pre-treatment, patients had an average RL FST sensitivity between 15-20dB, with two patients (aged 6 and 9) having zero sensitivity. Similarly, patients' pre-treatment BL FST sensitivity ranged from 15-25dB (on average), excluding three patients who had zero sensitivity. Significantly, all patients had increased BL sensitivity after treatment (with a minimum of 30dB), and majority had increased RL sensitivity. Interestingly, the 7-year-old patient lost all sensitivity to RL post-treatment, but gained previously non-existent BL sensitivity (of 48dB). Moreover, two of the oldest patients (aged 28 and 42) had slightly reduced RL sensitivity post-treatment, from 19dB and 16dB, to 14dB and 12dD, respectively. Based on this data, treatment is less effective in patients over 18, who had an average BL FST of 35dB post-treatment (compared to 52dB for patients under 18). Significantly, the 18-year-old patient reached the control's FST BL sensitivity post-treatment, though they had the highest sensitivity pre-treatment. This demonstrates how treatment effectiveness is dependent on each patient's condition (e.g. stage of disease and cumulative retinal damage), rather than guaranteeing a certain level of improvement for all cases.

One limitation is the small sample size (13 patients) which only includes four patients over 18, and thus does not adequately demonstrate Luxturna's effectiveness on older patients, who typically have severer vision loss due to RPE-RD's degenerative nature (displayed in Source 1 and 2). Although FST is accurate in assessing vision, it only represents maximal sensitivity and does not detect local improvements/losses (Aleman et al., 2020). Overall, this study demonstrates Luxturna's immediate effects, significantly increasing BL and RL FST sensitivity in majority of patients, causing improved vision.

The following excerpt demonstrates insightful discussion of the quality of evidence.

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

Evidence provided by Hütter et al. (2009), Gupta et al. (2020) and Hsu et al. (2023) demonstrates the effectiveness of transplanting the CCR5-Δ32 mutation in significantly reducing HIV viral load, with HIV going into long-term remission in all trials. Additionally, given that all three studies were published in peer-reviewed journals including the New England Journal of Medicine, The Lancet, and Cell, their validity in answering the research question is increased. Furthermore, evidence from Capoferri et al. (2022) details the failure of a stem cell treatment, without CCR5-Δ32 donor cells, in achieving long-term HIV remission. This finding is useful in addressing the research question as it demonstrates the specific importance of the CCR5-Δ32 gene in curing HIV.

Overall, the evidence investigated demonstrates that stem cell transplantation of the CCR5-Δ32 mutation results in long term remission for HIV in all cases, thus successfully answering the research question and responding to the claim. However, multiple limitations of the evidence must still be considered. Firstly, the study conducted by Hütter et al. is somewhat limited given it was published in 2009, meaning that medical procedures used in the study could be outdated thus reducing its reliability. Regardless, the findings of the study around the usefulness of the CCR5-Δ32 mutation are corroborated by more recent studies (specifically that by Gupta et al.) reducing the impact of this limitation. Studies from Gupta et al. and Hsu et al. were less impacted by concerns around recency, with publication in 2020 and 2023 respectively. As a result, their reliability in addressing the research question is increased.

Separately, a significant limitation impacting the validity of evidence provided by Hütter et al. is the relatively small post-transplant period covered (549 days). In comparison, Gupta et al. and Hsu et al. cover periods of 1359 days and 1680 days. Additionally, differing durations of post-transplant monitoring presents a further limitation of the ability of the studies to corroborate results. While all studies do provide clear evidence demonstrating the effectiveness of transplanting the CCR5-Δ32 to achieve HIV remission, Hütter et al. (2009), Gupta et al. (2020) and Hsu et al. (2023) all investigate a single patient, meaning only three instances of HIV being cured via the mutation were studied in total. As a result of small sample sizes, the reliability of the evidence to answer the research question is severely limited. This limitation is likely due to the extremely small population of available donors homozygous to CCR5-Δ32.

Additionally, findings from Hütter et al. (2009) and Gupta et al. (2020) are limited in their ability to confirm the success of the CCR5-Δ32 at curing HIV across the broader population, as they both investigate middle-aged Caucasian men. While Hsu et al. (2023) somewhat addresses this limitation in evaluating transplantation in a mixed-race female, studies with more varied sample populations are required to confirm the conclusions of the research.

Regardless, the evidence provided is still able to suggest that the CCR5-Δ32 mutation can completely cure HIV in humans via stem cell transplantation. To confirm this conclusion numerous improvements and extensions can be implemented.

Additional advice

- Schools should ensure

  – accuracy and consistency in judgments when determining grades for each criterion by applying the best-fit approach (see Syllabuses app > QCAA Portal > *Using ISMGs for General Science syllabuses*). After determining the performance level that best fits the evidence matched to characteristics for a criterion within an ISMG, for a two-mark range performance level, the higher mark should only be awarded if there is evidence of all the characteristics in the performance-level descriptor (or better)

  – marked ISMGs indicate the characteristics evident in the student response and the mark awarded for each criterion (*QCE and QCIA policy and procedures handbook v6.0,* Section 9.6.1)

  – that strategies for responses that exceed syllabus conditions for length are developed and enacted. This includes annotating responses to show how the school's assessment policy has been applied (*QCE and QCIA policy and procedures handbook v6.0*, Section 8.2.6) .

- Students should be encouraged to revise the research question once the evidence is finalised to ensure it reflects the evidence that was obtained.

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.

External assessment — 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 (27 marks)

- Paper 2, Section 1 consisted of short response questions (50 marks)

Assessment decisions

Assessment decisions are made by markers by matching student responses to the external assessment marking guide (EAMG). The external assessment papers and the EAMG are published in the year after they are administered.

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.

Question	A	B	C	D
1	**90.54**	4.96	2.74	1.71
2	7.85	**64.13**	17.48	10.39
3	17.54	**58.19**	12.07	11.97
4	9.96	5.71	**74.82**	9.38
5	**55.22**	15.32	19.61	9.55
6	**55.17**	7.07	21.95	15.62
7	8.57	**73.12**	4.51	13.71
8	13.32	20.15	17.91	**48.42**
9	11.42	1.29	**86.47**	0.71
10	7.48	22.67	**46.88**	22.70

Question	A	B	C	D
11	8.94	**58.55**	6.48	25.86
12	25.26	14.79	19.13	**40.59**
13	**89.26**	2.12	4.48	4.02
14	**85.02**	7.12	5.40	2.32
15	5.64	1.53	13.63	**79.06**
16	27.09	2.04	**41.06**	29.63
17	5.76	43.49	11.49	**39.11**
18	8.65	**43.81**	15.16	32.15
19	12.14	32.67	9.92	**45.11**
20	8.73	12.78	**72.29**	6.04

Effective practices

Overall, students responded well to:

- items requiring analysis and interpretation of supplied data, e.g. energy flow diagram, cladogram, transect data and spindle graph

- items requiring application of formulas and algorithms to determine unknown quantities, e.g. calculating SDI, constructing and interpreting a Punnett square, and applying the Lincoln index.

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 the role of tRNA and how it carries out this function

  - explaining how the process of crossing over contributes to genetic variation

  - describing ways energy is transformed in an ecosystem

  - explaining how habitat fragmentation can lead to speciation

  - explaining how errors during DNA replication can lead to point and frameshift mutations

  - describing how gene expression is regulated

  - describing the process of ecological succession, distinguishing between primary and secondary succession

- ensure students use subject-specific terminology correctly, particularly when describing genetics concepts, e.g. 'allele' vs. 'gene'.

- incorporate exercises that focus on reading and responding appropriately to examination questions, emphasising the importance of cueing factors such as the cognitive verb, the number of marks, key terms in the question and relevant stimulus when planning responses

- provide opportunities for students to practise integrating knowledge and understanding of the syllabus subject matter to explain phenomena, e.g. why genetic mutations do not always affect the phenotype of an individual.

Samples

Short response

Paper 1, Question 26c)

The following excerpt is from Question 26c) in Paper 1. It required students to describe two ways energy is transformed in an ecosystem.

Effective student responses:

- described one way energy is transformed

- described a second way energy is transformed.

This excerpt demonstrates consideration of the cognitive verb, number of marks, key terms in the question and relevant stimulus to develop an appropriate response.

> One way energy is transformed in this ecosystem is the transformation of solar energy into chemical energy (in the form of glucose) via photosynthesis. Another way energy is transformed is from chemical energy (glucose) to thermal energy (heat) via the process of cellular respiration.
>
>   photosynthesis   respiration
> Solar energy ⟶ chemical energy ⟶ thermal energy

Paper 1, Question 27

The following excerpt is from Question 27 in Paper 1. It required students to determine the reliability of the capture–recapture technique using the Lincoln index.

Effective student responses:

- calculated *N* for the first researcher

- determined the expected *m* for the second researcher.

This excerpt demonstrates an appropriate response to an Objective 2 (Apply understanding) item requiring a calculation.

If the ~~reliabit~~ reliability is high, both researchers should record the same approximately

Population size.

Researcher I:

$N = \frac{M \times n}{m}$

$= \frac{160 \times 140}{80}$

$= 280$

∴ Researcher II approximately should also calculate $N = 280$

Researcher II:

$N = \frac{M \times n}{m}$

$280 = \frac{100 \times 60}{m}$

$m = \frac{100 \times 60}{280}$

$= 21.43$

≈ 21

∴ Researcher II should expect approximately 21 marked mice in the second capture.

Paper 2, Question 6b)

The following excerpt is from Question 6b) in Paper 2. It required students to identify evidence for the sickle-cell anaemia allele being advantageous for individuals living where malaria is prevalent and explain their reasoning.

Effective student responses:

- identified appropriate evidence

- explained the reasoning.

This excerpt demonstrates an appropriate response to an item requiring students to 'Explain [their] reasoning'.

From the maps, the frequency of the sickle-cell anaemia (SCA) allele is only greater than 1% in areas where malaria is present. This suggests that having the SCA allele provides a selective advantage for the selection pressure of malaria. Individuals with the allele would more frequently survive having malaria, allowing them to reproduce and pass on the allele, which explains the higher frequency of the allele in places where malaria is present. Therefore, there is evidence that the SCA allele is advantageous for individuals where malaria is prevalent.

Paper 2, Question 9b)

The following excerpt is from Question 9b) in Paper 2. It required students to describe the role of tRNA and explain how it carries out this function.

Effective student responses:

- described the role of tRNA

- described the role of anticodons

- tRNA-amino acid specificity.

This excerpt demonstrates appropriate use of subject-specific terminology.

> Structure IV is tRNA and is responsible for the translation of mRNA strands into a protein at the ribosome. tRNA has an anticodon attached at one end and a corresponding amino acid at the other. Through complementary base pairing, the anticodon on tRNA (composed of 3 nitrogenous bases) pairs with a complementary codon on the mRNA strand (set of 3 complementary bases). This is repeated along the mRNA strand, allowing the amino acids to form a peptide bonds to create a polypeptide chain (protein). The tRNA detach themselves from mRNA after this. This process is repeated until a stop Codon is reached.

Paper 2, Question 9d)

The following excerpt is from Question 9d) in Paper 2. It required students to explain two reasons why genetic mutations do not always affect the phenotype of an individual.

Effective student responses:

- provided a reason

- provided a second reason

This excerpt demonstrates integration of subject matter knowledge to explain phenomena.

> One reason why the genetic mutation may not affect the phenotype is that the mutation occurs in non-coding introns which do not get synthessed into proteins so no impact is seen on the phenotype. Another reason why is that the mutation may be a silent point mutation and therefore, the same amino acid is coded for so no change is seen to the polypeptide chain and therefore no change to the protein or the phenotype.