**NSW Education Standards Authority**

# 2021 HSC Science Extension Marking Guidelines

## Section 1

## Question 1

| Criteria | Marks |
|---|---|
| • Provides a comprehensive explanation of a variety of issues that might have led to the rejection<br>• Supports arguments with relevant reference to the abstract | 5 |
| • Provides a thorough explanation of issues that might have led to the rejection<br>• Supports arguments with reference to the abstract | 4 |
| • Demonstrates a sound understanding of issues that might have led to the rejection<br>• Provides some explanation of the issues<br>• Refers to the abstract | 3 |
| • Demonstrates a sound understanding of issues associated with the research<br>OR<br>• Provides an explanation of an issue | 2 |
| • Demonstrates an understanding of scientific research | 1 |

*Sample answer:*

There is no control group. This means that there is no way of knowing the effect of not taking prebiotics. All participants were aware that they were in the treatment group which could lead to confirmation bias or the placebo effect. Because the sample size of 11 is small, it is not necessarily representative of the whole population, especially since there is no mention of how the participants were selected. There is no mention of potential confounding variables and the general term 'healthy' is all that is given.

The independent variable, diet with prebiotics, was not kept constant between participants leading to a different experiment on each participant. The amount of prebiotic food taken was not prescribed and there was no check on adherence to the diet.

The data collected is self-reported by the test subjects using a questionnaire, including weight measurements. None of the data was validated by the researchers. The questionnaire also relied on self-reporting for health and wellbeing. It is not clear whether this was based on an arbitrary scale or direct measurements. No formal tests to determine emotional wellbeing improvement were undertaken. Positive changes in gut bacteria were not quantified and no statistical values were reported in the abstract. Without such data the conclusion that there is a link between prebiotics and the diet is not supported.

*Answers could include:*

There are numerous issues with the methodology of the research presented such that the conclusions are unlikely to be valid.

- Significant weight reduction determined by t-test not clearly described.  No information on how many individuals lost weight or the amount of weight lost.
- Indicators such as improved digestion or fewer digestive disorders are unfounded claims based on the individual's opinion.
- The term 'commonly reported' is vague and may not constitute a significant difference.
- Length of time, five weeks, is relatively short and longer-term studies might show different results.

# Question 2

| Criteria | Marks |
| --- | --- |
| • Provides a comprehensive explanation of how induction and deduction can be used to test the idea | 3 |
| • Demonstrates a thorough understanding of how induction or deduction can be used to test the idea<br>OR<br>• Demonstrates a sound understanding of how induction and deduction can be used to test the idea | 2 |
| • Demonstrates an understanding of induction and/or deduction | 1 |

*Sample answer:*

The school can identify similar schools that have increased the number of recycling bins, and review their data on the number of items recycled. Induction is used as the school applies the findings from a specific context to a different context.

Alternatively, the school could gather its own data. It could count the number of items recycled before and after the increase in recycling bins. Deduction is used as the school analyses data gathered in its own specific context to form a conclusion.

# Question 3

| Criteria | Marks |
|---|---|
| • Demonstrates a comprehensive understanding of how data can be used to support a hypothesis<br>• Makes an informed judgement based on thorough analysis of Sources 1 and 2 | 5 |
| • Demonstrates a thorough understanding of how data can be used to support a hypothesis<br>• Makes a judgement based on sound analysis of Sources 1 and 2 | 4 |
| • Demonstrates a sound understanding of how data can be used to support a hypothesis<br>• Interprets some evidence from Sources 1 and/or 2 | 2–3 |
| • Demonstrates some understanding of the data and how it relates to the hypothesis | 1 |

*Sample answer:*

Source 1 shows the majority of long-term surveys used in this analysis have been conducted in Europe and USA, so the data is geographically biased. There is little data from the southern hemisphere or tropical regions. The results cannot be extrapolated to the world because different countries have different industries which influence the concentration of heavy metals in waterways.

The mean annual rate of increase in the concentration for all heavy metals reported in Source 2 over 40 years is about 2.5%. The range is small. If the increase is steady, then the concentrations of heavy metals may increase to the point that the hypothesis will then be supported. However, if the rate of increase is close to zero for several years (eg arsenic) in the countries studied, there may be no constant trend, which will not support the hypothesis. Indeed, the rate of increase in concentration may change with the location of the study, resulting in inconsistent concentration changes of heavy metals in waterways as seen in the large ranges and presence of an extreme outlier for arsenic.

Despite an increase in the concentration of heavy metals recorded in long-term studies, the results do not support the hypothesis because of the large variance in the data and limited geographical sampling.

# Question 4

| Criteria | Marks |
|---|---|
| • Demonstrates comprehensive understanding of experimental design including hypothesis and the collection, analysis and representation of data<br>• Demonstrates a clear distinction in how qualitative and quantitative data from digital images/videos are collected, analysed and represented in the proposed experiment<br>• Proposes a hypothesis that can be tested by the proposed experiment | 7 |
| • Demonstrates a thorough understanding of experimental design including hypothesis and the collection, analysis and representation of data<br>• Distinguishes between collection, analysis and representation of qualitative and quantitative data from digital images/videos in the proposed experiment<br>• Proposes a hypothesis that can be tested | 6 |
| • Demonstrates a sound understanding of experimental design including the collection and treatment of data<br>• Demonstrates an understanding of qualitative and quantitative data<br>• Proposes an experiment using digital images/videos<br>• Proposes a hypothesis | 4–5 |
| • Demonstrates an understanding of experimental design and/or the treatment of data<br>• Proposes a hypothesis and/or an experiment to collect qualitative and/or quantitative data | 2–3 |
| • Demonstrates an understanding of experimental design and/or qualitative and/or quantitative data | 1 |

***Sample answer:***

A chemical reaction that uses hydrogen ions (the solution becomes less acidic as the reaction proceeds) can be visualised by adding Universal Indicator (UI). Both the qualitative colour change and the quantitative rate of change can be detected by cameras.

Hypothesis. A chemical reaction proceeds faster at higher temperatures.

Method.

Set up a beaker containing a solution with known concentration (2 mol $L^{-1}$) of nitric acid at room temperature ($25^{o}C$). Add three drops UI to form a red solution.

Set up a fixed camera to photograph the beaker with solution every 0.1s.

Start the camera.

Add a known quantity of calcium hydroxide (1 mol $L^{-1}$).

As the reaction proceeds, the solution will become less acidic and change colour to green (qualitative data: colour change).

$Ca(OH)_{2(aq)} + 2HNO_{3(aq)} \rightarrow Ca(NO_3)_{2(aq)} + 2H_2O_{(l)}$
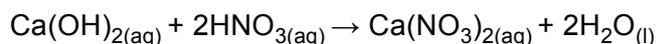
When there is no more change in colour, stop the camera.

Count the frames of the camera (every 0.1s) to establish the time taken for the reaction (quantitative data).

Repeat the experiment at $10^{o}C$.

Compare the results at the two different temperatures.

Repeat the experiment at both temperatures nine times.

Analysis and Representation

Qualitative results. Categorise the colour of the solution before calcium hydroxide was added and when the reaction was complete according to the colour chart of UI. Plot the frequency of each colour at both temperatures on a histogram with each colour from the UI colour chart forming the categories along the *x*-axis.

Quantitative results. Calculate time taken from addition of calcium hydroxide to final colour change for each trial at both temperatures. Present data in a table including mean and standard deviation of time at each temperature. Perform a student's t-test on the data to compare the mean time at $10^{o}C$ and $25^{o}C$. If the calculated t-value is larger than the critical t-value for $p = 0.05$ and 9 degrees of freedom, then the hypothesis would be accepted.

***Answers could include:***

- Shape and rate of crystal formation
- Rate of land clearing of different vegetation types
- Rotational velocity of galaxy types
- Distribution and abundance of nocturnal animals in an area
- Distance from target vs accuracy in archery.

# Section 2, Part A

## Question 5 (a)

| Criteria | Marks |
|---|---|
| • Provides a comprehensive explanation of why political, economic and ethical factors might influence the conduct of the experiment<br>• Refers to information from the video and the map | 6 |
| • Demonstrates a thorough understanding of why political, economic and ethical factors might influence the conduct of the experiment<br>• Refers to information from the video and the map | 5 |
| • Demonstrates a sound understanding of why political, economic and ethical factors might influence the conduct of the experiment with reference to information from the video and/or the map<br>OR<br>• Demonstrates a thorough understanding of why TWO of the factors might influence the conduct of the experiment with reference to information from the video and/or the map | 4 |
| • Demonstrates a sound understanding of the political and/or economic and/or ethical factors that might influence the conduct of the experiment<br>• Uses information from the video and/or the map | 2–3 |
| • Demonstrates some understanding of the political and/or economic and/or ethical factors that might influence the conduct of the experiment | 1 |

*Sample answer:*

The largest influence on the decision to proceed with the experiment may be political. Because of the location of the proposed study area, and the proposal to move the dingo fence, three different state governments would need to agree.  The dingo fence has been in existence since the 1880s, and to move it would require new political agreements. Since different states could have different laws for handling dingoes, approval of such a large-scale experiment would require common goals. In addition, states could have different regulations with respect to the ethics of conducting such an experiment. While in many areas dingoes are killed as a pest animal, once a predator such as this is reintroduced into an area experimentally, the prey killed by them may be considered a result of the experiment. Since vertebrates are covered by animal ethics legislation, the experiment may require animal ethics approval.

There would be strong opposition from sheep farmers who fear their livestock will be killed by the dingoes, and who will put pressure on law-makers to continue to cull them. If the dingoes kill the farmers' livestock, there may be large economic losses for farmers. On the other hand, the re-introduction of dingoes may cause a reduction in numbers of kangaroos and feral goats that compete with sheep for grazing pasture, benefiting the farmer. An understanding of these competing economic interests will determine whether the experiment gains approval.

# Question 5 (b)

| Criteria | Marks |
|---|---|
| • Demonstrates accurate interpretation and effective processing of scientific and statistical data<br>• Makes an informed decision about whether the scientists should proceed with the experiment<br>• Supports a variety of arguments using evidence provided in Sources 1 and 2 | 6 |
| • Demonstrates accurate interpretation of scientific and statistical data<br>• Makes a decision about whether the scientists should proceed with the experiment<br>• Supports arguments using evidence provided in Sources 1 and 2 | 5 |
| • Demonstrates comprehension of scientific and statistical data<br>• Supports arguments using evidence provided in Source 1 and/or Source 2 | 4 |
| • Demonstrates a sound understanding of scientific and/or statistical data<br>• Refers to Source 1 and/or Source 2 | 2–3 |
| • Demonstrates an understanding of the scientific basis of Source 1 or Source 2 | 1 |

*Sample answer:*

An experiment to test if small mammal extinctions in Australia can be reduced is worthwhile from a scientific viewpoint. Re-introduction of the dingo is predicted to improve vegetation and the diversity of species, especially for species that rely on ground cover for shelter. This prediction is supported by data in Source 1 which shows vegetation is grazed more extensively in unfenced plots than fenced plots where dingoes are rare. Vegetation growth in the plots was compared using a chi-squared test which showed the probability that the growth is the same in both plots is <0.001 and the hypothesis that there is a difference must be accepted. The difference can be explained by the increased numbers of grazing species such as kangaroos where dingoes are rare.

On the side of the fence where dingoes are common, vegetation growth is similar in fenced and unfenced plots ($p > 0.05$). The results can be explained by reduced grazing pressure on this side of the fence, which would lead to greater vegetation growth in both plots.

Introduced foxes and cats are deadly predators on many small animals in Australia. Source 2 shows that where dingoes are abundant, foxes are few. There is a close, inverse relationship between the numbers of foxes and dingoes shown by the correlation coefficient ($r = -0.906$). This data provides a scientific basis for proceeding with the experiment. However, these data were collected in forested areas in eastern Australia and more data are needed to measure the relationship found in Central Australia.

## Question 5 (c)

| Criteria | Marks |
|---|---|
| • Provides a comprehensive explanation of features of the data required | 3 |
| • Demonstrates a sound understanding of features of the data required<br>OR<br>• Provides a comprehensive explanation of a feature of the data required | 2 |
| • Demonstrates an understanding of predictive data modelling | 1 |

*Sample answer:*

Data will need to be collected over a long period of time so trends in species diversity can be accurately tracked. Increasing the quantity of data improves the predictive capability of the model.

A large data set that accounts for various conditions needs to be used. This accounts for variability in the data in this environment where climatic factors such as rainfall can have large effects on animal and plant populations being monitored.

# Section 2, Part B

## Question 6

| Criteria | Marks |
|---|---|
| • Demonstrates extensive knowledge and understanding of the processes used in scientific research<br>• Provides a comprehensive explanation of how scientific research can build and preserve trust<br>• Supports explanation with reference to the student's experience in carrying out a scientific research project<br>• Communicates ideas and information using appropriate scientific language<br>• Presents a logical and coherent response | 13–15 |
| • Demonstrates thorough knowledge and understanding of the processes used in scientific research<br>• Provides a thorough explanation of how scientific research can build and/or preserve trust<br>• Includes relevant aspects of the student's experience in carrying out a scientific research project to support answer<br>• Communicates ideas and information using scientific language<br>• Presents a logical response | 10–12 |
| • Demonstrates developed knowledge and understanding of the processes used in scientific research<br>• Demonstrates a sound understanding of how scientific research can build and/or preserve trust<br>• Includes some aspects of the student's experience in carrying out a scientific research project<br>• Presents a structured response using scientific language | 7–9 |
| • Demonstrates sound knowledge and understanding of processes used in scientific research<br>• Demonstrates an understanding of the link between scientific processes and building and/or preserving society's trust<br>• Makes some reference to the student's experience in the scientific research project<br>• Uses some scientific language | 4–6 |
| • Demonstrates an understanding of processes used in scientific research<br>• May refer to the student's experience in the scientific research project | 1–3 |

*Sample answer:*

Scientific research relies on rigorously testing theories, ideas or anecdotes. It is the way the tests are done that builds and preserves trust. Several different reliable methods are used to gather evidence which is analysed extensively by a number of different people or research groups. It is the collective decision from different scientists after independent testing of the idea that builds trust in the process.

A scientific idea is framed as a hypothesis – a statement of the likely result, which must be testable and falsifiable. That is, it must be possible to record data that supports or denies the

hypothesis and therefore informs the final conclusion. In my scientific research project, my hypothesis was: as the temperature increases in a closed system, the viscosity of the polyvinyl borate decreases, which was supported by the experimental data gathered.

The data is further tested using statistical tests to indicate quantitatively the strength of the relationship between the variables or the confidence in the data to support the conclusion. In other words, how likely it is to have occurred by chance. In my scientific research project, I tested the correlation between temperature and viscosity, using Pearson's correlation coefficient. The r value of 0.942 demonstrated that viscosity was strongly correlated to the variance in temperature and supported my conclusion.

Other processes that build trust in science include repetition and testing one variable at a time while keeping others constant. For example, I changed only one variable, temperature, while viscosity was measured and variables such as density and radius of the sphere were kept constant. The experiment was repeated five times. In addition, a control experiment should be run where no variables are changed and any change in measurements, in my case viscosity, are noted, to eliminate the argument that the changes measured may have occurred with no intervention.

My project used established processes to determine the trustworthiness of the result. However, trust is magnified when this experiment is viewed in the light of similar scientific experiments reported in the scientific literature and when it is repeated by others to confirm the result, using both the same and different methods. Also, before being accepted for publication in a scientific journal, a paper is peer reviewed. Experts in the field critique the methodology, the statistical analysis and the conclusions. This process means that every report is checked by other scientists before publication and faulty claims are scrutinised and rejected. It is difficult to gain approval for and publication of new data supporting new ideas or a paradigm shift in thinking, as scientists themselves distrust results that have not been confirmed.

While publication of research in scientific journals is the first step in disseminating information in a trusted form, these journals are mainly read by scientists and the information does not reach wider society. Communication of science to society is most important in building and preserving trust. Communication needs to be regular, in language that can be understood by the various audiences and widespread on mainstream media. Science that has been well tested must be presented without bias, either political, industrial or economic.

The scientific process is designed to be valid and build trust, and it takes repetition and scrutiny from other scientists to be accepted. Preserving trust in science by society requires unbiased, consistent communication to the broader public.

***Answers could include:***

Literature review – search for information
• Based on reliable sources

Methodology
• Double placebos tests
• Use large data sets.

# 2021 HSC Science Extension Mapping Grid

## Section 1

| Question | Marks | Content | Syllabus outcomes |
|---|---|---|---|
| 1 | 5 | M2: Methodology and Data Collection<br>M3: Decisions from Data and Evidence | SE–1, SE–5 |
| 2 | 3 | M1: The Development of Modern Science | SE–2 |
| 3 | 5 | M3: Patterns and Trends<br>M3: Decisions from Data and Evidence<br>M4: Reporting Findings | SE–1, SE–5, SE–6 |
| 4 | 7 | M2: Methodology and Data Collection<br>M2: Processing Data for Analysis<br>M3: Patterns and Trends<br>M3: Statistics in Scientific Research | SE–1, SE–3 |

## Section 2, Part A

| Question | Marks | Content | Syllabus outcomes |
|---|---|---|---|
| 5 (a) | 6 | M1: Influences on Current Scientific Thinking | SE–2 |
| 5 (b) | 6 | M2: Developing the Question and Hypothesis<br>M2: Scientific Research Proposal<br>M3: Statistics in Scientific Research<br>M3: Decisions from Data and Evidence | SE1, SE–4, SE–5, SE–6, SE–7 |
| 5 (c) | 3 | M3: Data Modelling | SE–4 |

## Section 2, Part B

| Question | Marks | Content | Syllabus outcomes |
|---|---|---|---|
| 6 | 15 | M1: The Development of Modern Science<br>M2: Methodology and Data Collection<br>M3: Decisions from Data and Evidence<br>M4: Reporting Findings | SE–1, SE–2, SE–5, SE–7 |