2020 HSC Science Extension Marking Guidelines

Section 1

Question 1

Criteria	Marks
• Demonstrates extensive knowledge and understanding of the development of scientific research • Explains a variety of changes in scientific research over time • Supports answer with reference to the information from the table	6
• Demonstrates thorough knowledge and understanding of the development of scientific research • Describes changes in scientific research over time and provides explanation of most of the changes • Supports answer with reference to the information from the table	5
• Demonstrates developed knowledge and understanding of the development of scientific research • Describes changes in scientific research over time and provides explanation of some of the changes • Refers to relevant information from the table	4
• Demonstrates sound knowledge and understanding of the development of scientific research • Describes changes in scientific research over time • Refers to information from the table	2–3
• Demonstrates an understanding of how scientific research has changed over time	1

Sample answer:

From the late 19th century to now, there has been increased collaboration in the process of scientific research. This is evident in the number of authors. Papers 1 to 4 have up to 3 authors and Papers 5 to 7 have between 5 and 18 authors. The growth of the internet, the ability of international researchers to interact online, and the use of big data have facilitated collaboration between researchers. The use of increasingly expensive and complex scientific

technological equipment has also required the input of more researchers with different expertise. The impact of technology is more evident in the more recent papers.

The increased use of digital technology for communication not only leads to collaboration between scientists but also how scientific research is disseminated to society. The most recent paper was published as 'open access'. Papers and journals are also more likely to be published online nowadays.

There has been a shift in scientific research over time to build on previous research and findings. Early papers (eg 1–4) provided the fundamental knowledge on which contemporary research could be built. Later papers (eg 5–7) have increasingly more specific and specialised subjects. For example, the 1922 paper showed how insulin could be used in the treatment of diabetes. In 2019, scientists studied the genes responsible.

Question 2

Criteria	Marks
• Demonstrates a comprehensive understanding of the relationship between scientific evidence and paradigm shift in science • Makes an informed judgement based on thorough analysis of Sources A and B	7
• Demonstrates a thorough understanding of the relationship between scientific evidence and paradigm shift in science • Makes a judgement based on sound analysis of Sources A and B	6
• Demonstrates a developed understanding of the relationship between scientific evidence and paradigm shift in science • Interprets evidence from Sources A and B • Relates evidence to paradigm shift	4–5
• Demonstrates a sound understanding of the relationship between scientific evidence and paradigm shift in science • Interprets some evidence from Sources A and/or B	2–3
• Demonstrates an understanding of the relationship between scientific evidence and paradigm shift in science	1

Sample answer:

A paradigm shift is a fundamental change in the way of thinking about a topic. Scientific research is usually carried out within a prevailing framework of thinking (paradigm). A shift in the paradigm could occur if well-conducted experiments produce evidence that is not compatible with the current paradigm.

The paradigm presented is that the bacteria living within the gut have no effect on brain function. Source A appears to contradict this. In this study, after children with autism received a gut bacteria transplant, their symptoms decreased over two years. However, the study includes results from only 18 children and no information is provided as to how the children were selected and whether other variables and interventions were taken into account. There is no evidence of a control group to show what changes could be expected over two years in the absence of a transplant.

Source B reports a study of two groups of mice showing ‘normal’ or ‘impaired’ social behaviour. The authors measured differences in brain chemicals and nerve activity that correlated with the behaviour. The graph shows that the social behaviour of ‘impaired’ mice

was the same as ‘normal’ mice after a gut bacteria transplant, and the authors claim that brain chemicals and nerve activity also changed. These data are persuasive because they hint at a mechanism underlying a change in behaviour. However, this is a study on mice and it is not known whether the same data would be obtained in other species.

To establish a paradigm shift more evidence is required and a plausible mechanism by which gut bacteria could affect brain function would need to be established. The sources lead to the beginning of a new hypothesis but not a paradigm shift.

Question 3

Criteria	Marks
• Demonstrates comprehensive understanding of data sampling and statistical analysis • Makes an informed judgement based on information provided • Supports arguments using evidence from data sampling and statistical analysis	7
• Demonstrates thorough understanding of data sampling and statistical analysis • Makes a judgement based on information provided • Relates evidence from data sampling and statistical analysis to the judgement	6
• Demonstrates developed understanding of data sampling and statistical analysis • Interprets evidence from data sampling and statistical analysis	4–5
• Demonstrates sound understanding of data sampling and statistical analysis • Provides some interpretation of evidence from data sampling and/or statistical analysis	2–3
• Demonstrates an understanding of data sampling and/or statistical analysis	1

Sample answer:

The school authority has been presented with results from soil samples from the old paint factory site by three different groups. It could be argued that two of these groups are biased. The paint company, who may be keen to sell the site, and the RAG who are opposed to development on the site may have reported selected samples that support their desired results. For example, the RAG reported a mean lead concentration higher than the safety guidelines.

The three groups used different sample sizes. The independent consultancy only took 5 samples which may be too few to have confidence in the results. While the mean (241) is well below the level deemed safe, the standard deviation (SD) is large suggesting that some samples may have high lead levels. The large SD and small sample size would affect the p-value from the t-test (0.620), which indicated there is no difference between mean lead levels on the proposed school site compared with the surrounding area.

The methodology of the paint company appears to be the most reliable. They took the highest number of samples (30), returned a mean of 207 with a small SD of 26, suggesting there is less variation in the samples than the other groups. However, the p-value is only just above 0.05, the value at which it might be concluded that there is a difference between the

site and the surrounding area. Because of the mean results it is likely that the lead concentration is lower on the proposed site than the surrounding area. This contradicts the RAG results which show a significantly higher concentration on the proposed site (p=0.046).

Because of the conflicting nature of the results and the possible bias from some of the groups, the school authority should not have confidence in the results presented.

Section 2, Part A

Question 4 (a)

Criteria	Marks
• Provides a comprehensive explanation of the benefits of using big data sets such as those collected by weather radar technology • Relates benefits to the study of bird migration	3
• Provides an explanation of the benefits of using big data sets OR • Provides a description of the benefits of using big data sets, relating benefits to the study of bird migration	2
• Demonstrates an understanding of the benefits of using big data sets	1

Sample answer:

Studying bird migration with weather radar data allows for continuous monitoring of movements from many species over the year. Therefore the precise timing of migratory movements can be recorded.

Large data sets can be collected over long time periods eg spring and autumn data can be replicated each year over 24 years. Long-term changes of migration can be correlated with other climatic factors such as temperature.

Large data sets are unlikely to be open to sampling bias as the radar detects flocks of birds moving, independent of landing sites or losses of individual birds.

Because of the large volume of data that is averaged, outliers have minimal effect on the overall data. Unusual behaviour of individual birds would not affect the overall results.

Question 4 (b)

Criteria	Marks
• Demonstrates comprehensive knowledge in interpreting data for trends and patterns • Demonstrates comprehensive understanding of the extent to which the results support the predictions • Justifies the answer with reference to trends, patterns and statistics	5
• Demonstrates thorough knowledge in interpreting data for trends and patterns • Demonstrates thorough understanding of using results to confirm predictions • Justifies the answer with reference to trends, patterns and/or statistics	4
• Demonstrates developed knowledge in interpreting data for trends and patterns • Demonstrates developed understanding of using results to confirm predictions • Supports the answer with reference to the results	3
• Demonstrates sound knowledge in interpreting data for trends and patterns • Demonstrates some understanding of using results to confirm predictions	2
• Demonstrates an understanding of trends and patterns in data and/or using results to confirm predictions	1

Sample answer:

The spring results support the scientists' predictions whereas the autumn results do not.

In spring, the timing of bird migration has become earlier by 0.25 to 1.5 days per decade on average, supporting the prediction that migration would become earlier. Since the change in timing is less at lower latitudes (change at 30°N = –0.26; change at 45°N = –1.53), the prediction that changes would be greater at higher latitudes is also correct. However the total change is small, less than 2 days per decade. Statistical analysis would be required to determine whether these changes are statistically significant.

In autumn, the changes in migration are less than in spring and the trend is more variable (change at 45°N is less than that at 40°N). The direction of change in autumn is unexpected. The timing of bird migration has become earlier by 0.5 to 0.8 days per decade on average, which does not support the prediction that migration would be later. The change in migration is greater at higher latitudes (change at 45°N = –0.73; change at 30°N = –0.47) but the differences are small and do not strongly support the prediction that the greatest changes will be seen at higher latitudes.

Question 4 (c)

Criteria	Marks
• Demonstrates extensive understanding of establishing causation in a scientific study • Explains the requirements to establish causation • Applies the requirements to the relationship between changes in migration dates and changes in temperature	7
• Demonstrates thorough understanding of establishing causation in a scientific study • Explains most of the requirements to establish causation • Relates some requirements to establish causation to the relationship between changes in migration dates and changes in temperature	6
• Demonstrates developed understanding of establishing causation in a scientific study • Describes some of the requirements to establish causation • Links some requirements to the scenario	5
• Demonstrates sound understanding of establishing correlation and/or causation in a scientific study • Describes some requirements to establish correlation/causation and/or links some requirements to the scenario	3–4
• Demonstrates an understanding of correlation and/or causation in a scientific study	1–2

Sample answer:

To establish causation, three primary requirements need to be met.

Firstly, the scientists showed that as temperatures rose over the decades, the time that birds migrate changed. Therefore, the variables are correlated.

Secondly, the rise in temperature must precede the tendency for birds to migrate early. This is difficult to establish because of the long time scales and potential variability in daily temperatures. It is not possible to reverse the temperature trend and see if the time of migration reverts to former measurements, which would help to establish causation. However, temperature has consistently risen since 1995 and the migration date has moved in line with this, suggesting it is possible that temperature rise causes migration time to change.

Thirdly, the scientists need to eliminate other variables that could be causing the outcome. In this study eliminating other variables is problematic as the data has been analysed from a large data set and it is not possible to set up a controlled experiment. However, they have shown consistency of response. Also, the effect is stronger in areas where the temperature change is larger, at higher latitudes. This strengthens the case for causation.

Temperature is only one variable that indicates a change in climate. Other variables such as rainfall, humidity or wind direction may also change and interact with temperature, leading to changes in insect numbers or seed production. Hence a suite of associated factors could be responsible for the observed results, suggesting that indirect causation is plausible.

It is difficult for any one study to satisfy all factors to establish causation. The data presented suggests that causation exists but the lack of controlled experimentation and lack of other supporting studies preclude making a definite conclusion.

Section 2, Part B

Question 5

Criteria	Marks
• Demonstrates extensive knowledge and understanding of the process of scientific research • Provides a comprehensive evaluation of the scientific research proposal • Supports evaluation with reference to the student's experience in developing a scientific research proposal for the scientific research project • Communicates ideas and information using appropriate scientific language • Presents a logical and coherent response	13–15
• Demonstrates thorough knowledge and understanding of the process of scientific research • Provides a thorough evaluation of the scientific research proposal • Includes relevant aspects of the student's experience in developing a scientific research proposal for the scientific research project to support answer • Communicates ideas and information using scientific language • Presents a logical response	10–12
• Demonstrates developed knowledge and understanding of the development of a scientific research proposal • Includes some aspects of the student's experience in developing a scientific research proposal for the scientific research project • Presents a structured response using scientific language	7–9
• Demonstrates sound knowledge and understanding of the development of a scientific research proposal • Makes some reference to the student's experience in the scientific research project • Uses some scientific language	4–6
• Demonstrates an understanding of the development of a scientific research proposal • May refer to the student's experience in the scientific research project	1–3

Sample answer:

The aim of the project is to provide stronger and more flexible surfaces for use in personal armour or satellites, inspired by an unusual animal that has developed a strong flexible surface for the conditions in which it lives. Mimicking such a surface has clear applications for the production of new surfaces and has the potential to advance knowledge. In my own research proposal to study the impact of introduced weeds on invertebrate survival, I had to explain what experiments had been done by others and how mine were different. This proposal fails to justify the need for, and advantages of any new materials such as these, by failing to outline what is already available and the differences in the new materials.

No background is provided. In my own research proposal it was not until I had read several current journal articles and spoken to scientists on the topic of toxicity of weeds, that I could

form a question that would give new information. In this proposal, there is no reference to similar studies or what is known about the surfaces they are trying to produce.

The proposal does not outline the methodology to be used, nor any scientific testing of any new material developed. No clear hypotheses are proposed, nor is there a detailed plan of how the research will proceed, nor the time necessary to undertake the project. It is not clear whether the scientists have all the equipment to carry out the project. Overall, much more detailed methodology is required. Before I was allowed to proceed with my project I had to outline the experiments, the variables that would be measured and the equipment to be used and a timeline that was feasible in Year 12. I set up control experiments under the same conditions. All these details are missing from the proposal here.

What data will be gathered and how it will be analysed is missing from the proposal. A proposal should suggest detailed experiments with appropriate statistical analysis of results. Testing the strength of a snail's shell and its chemical composition may be important steps but how the results would be used to make new materials is not clear. I had to repeat my experiments several times to ensure the different toxicity of different weeds could be analysed using an analysis of variance, and when the results showed statistical differences I could make clear recommendations about which weeds were the most toxic. In this proposal, how the results will lead to a positive outcome is not stated.

It would appear that the layered structure of the snail shell has been analysed previously and so it is not clear why it is necessary to collect 100 snails to repeat this. It should be made clear how the soft tissue of the snail will affect the results from the indentometer, how the snails will be kept and whether they will be killed. The ethics of collecting large numbers of an endangered species known from only three locations worldwide is questionable and this part of the project requires much more justification than is provided. In my own project where I used invertebrates and exposed them to potentially toxic weeds, I had to justify use of these animals to my teacher. I was not allowed to use any vertebrates in my study because of laws on animal experimentation.

In my opinion, the desired outcome of new flexible, strong materials for the space industry or military use is not likely to result from this research proposal.

Answers could include:

- Methodology
- Difficulty and cost of collecting snails
- Lack of detail eg ‘compounds containing different metal’, ’type of iron sulphide … will be analysed’
- Expertise and equipment required
- Ethics – endangered snails
- No clear scientific research question or hypothesis
- No justification for research
- No literature review/assessment of current state of research
- No timeline, plan, benchmarks
- Collaboration with other scientists
- Experience in developing a scientific research proposal.

2020 HSC Science Extension Mapping Grid

Section 1

Question	Marks	Content	Syllabus outcomes
1	6	M1: Influences on Current Scientific Thinking M2: Developing the Question and Hypothesis M2: Scientific Research Proposal M4: Reporting Findings	SE-2
2	7	M1: Development of Modern Science M3: Decisions from Data and Evidence	SE-1, SE-2, SE-6
3	7	M2: Methodology and Data Collection M3: Statistics in Scientific Research M3: Decisions from Data and Evidence	SE-1, SE-4, SE-5

Section 2, Part A

Question	Marks	Content	Syllabus outcomes
4 (a)	3	M2: Methodology and Data Collection	SE-6
4 (b)	5	M3: Patterns and Trends M3: Decisions from Data and Evidence	SE-5, SE-6
4 (c)	7	M3: Patterns and Trends M3: Statistics in Scientific Research M3: Decisions from Data and Evidence	SE-4, SE-6, SE-7

Section 2, Part B

Question	Marks	Content	Syllabus outcomes
5	15	M2: Scientific Research Proposal M2: Methodology and Data Collection M4: Reporting Findings	SE-1, SE-2, SE-3, SE-7