

## BIOLOGY

### Overall grade boundaries

<b>Grade:</b>	E	D	C	B	A
<b>Mark range:</b>	0 - 7	8 - 15	16 - 22	23 - 28	29 - 36

### The range and suitability of the work submitted

In this session essays were submitted in a wide range of appropriate topics including microbiology ( effects of a wide range of commercial and natural antibacterial agents), plant growth (effects of a range of chemicals and physical conditions on growth), factors affecting germination and growth of seedlings (although often accompanied by some confusion about what constitutes germination versus what constitutes growth), biochemical investigations (especially activity of enzymes) , behavioural studies in invertebrates, fish and mammals, a variety of human biology topics (including behaviour, memory, exercise physiology, perception of stimuli, and nutrition), studies based on a particular disease and ecological studies based on particular local phenomena or environmental issues.

The current guide contains clear advice about the unsuitability of topics dealing with symptoms and treatment of particular human diseases. Nevertheless this type of essay continues to be reasonably common. In some cases students set out to deal with the biological basis of the disease but end up providing a detailed account of symptoms and treatments. This rarely, if ever, leads to a successful essay. Similarly, topics that do not have a strong biological basis such as ethical issues related to particular kinds of research, different approaches to medicine, surveys of attitudes to biological issues or the treatment of biological issues in the media, rarely lead to successful essays. Some very weak essays continue to be submitted in areas such as ethical issues, often only vaguely related to biology, the effects of music on living organisms as well as issues relating to health and fitness where both the time frame for the investigation and the sample size are inadequate.

Coordinators and supervisors should be aware of the particular problems related to essays dealing with the impact of a particular diet or of consumer products such as caffeine, coffee and energy drinks and, vitamin supplements on athletic performance and/or memory. Many of these studies are superficial and rely on small sample sizes and are therefore unlikely to lead to meaningful outcomes. The related ethical issues are more worrying as there is often no evidence of any consideration having been given to possible health effects on the subjects and rarely is there any evidence of informed consent having been obtained.

Studies based on the effects of herbal treatments on memory or performance are unlikely to yield meaningful data especially within the limits of sample size and study / control group participants available to students at this level. Students should also steer clear of topics such as creationism, intelligent design, personal injuries, alternative medicines or studies based on performance in a particular sport as most essays of this type turn out to be either strongly biased or even trivial.

A biology extended essay must have a significant biological component: the topic and research approach must be firmly biological. This is particularly significant for those criteria that carry specific reference to the "subject in which the essay is registered". These include criteria C, D F and G. The top level of criterion C refers to "appropriate" sources and data as well as "relevant" material. Examiners interpret this to mean relevant and appropriate within the biological context. In addition, a "well planned investigation" will use a recognizable biological methodology. For criterion D, the top level requires that the essay locates the investigation clearly and precisely in an "academic" context, in other words it must have a clear "biological" context. In addition the knowledge and understanding demonstrated should be biological. As far as criterion F is concerned, "appropriate analytical and evaluative skills" are those that are typically biological, such as the use of deductive reasoning, graphical analysis and statistical approaches.

Essays based on practical work carried out at a university or other research institution, have become less common but continue to be submitted. The current guide makes it very clear that essays of this type must be accompanied by a covering letter from a qualified person at the external institution but examiners continue to report that in the vast majority of cases, this requirement is not met. A cover letter should outline the role of the candidate in deciding the research approach as well as the type and extent of guidance provided at the institution. The person responsible should be made fully aware of the nature of the extended essay requirement. The experience of this and past sessions has shown that in some cases such essays have not been able to reach the top levels for certain criteria. This applies for example to criterion C where the assessment statement "the investigation has been well planned" is interpreted to mean well planned by the candidate. Often these essays have highly technical introductions and extensive protocols about one or other complex procedures. It is often evident that the terminology and description of the method is beyond the student's understanding but it is nonetheless described and is a major part of the EE. This is inappropriate. When work of this type is submitted, clear evidence must be provided (in the form of a covering letter), that the candidate has had a sufficient level of input into decisions about the research approach and selection of methodology and sources. The candidate should justify these decisions within the text of the essay. The person(s) responsible at the outside institution should be aware of the extended essay requirements and be asked to ensure that the candidate will have ample opportunity to plan and work independently.

Essays which are essentially literature-based narratives, where the student's contribution is confined to assembling the information from (usually) popular literature or web-based sources, continue to be submitted. While examiners search for qualities in these essays that show some merit, and try to reward these, it is often difficult for work of this type to perform well against the assessment criteria (particularly D, E and F). Students at this level rarely have the knowledge or skills to put their personal stamp on data or information that they have obtained from experts or to provide a critical evaluation of the methodologies used or the findings that have been presented. As a result they often end up simply repeating the perspective of the expert whose work they find most persuasive, and reaching a conclusion which is effectively little more than their personal opinion.

Extended essays in biology must comply with the *IB Animal experimentation policy*. This outlines minimum standards related to working with animal and human subjects. These standards apply regardless of whether the work is carried out on site or at a research

institution or university which might have more far-reaching approval with regard to animal research. In this session, essays which breached these ethical principles included drawing and examining human blood sample, working with human semen and vaginal mucus, injecting rats with alcohol and then drawing blood to test for lipids as well as experiments that resulted in mortality of insects. Incubating microorganisms at or near body temperature is inappropriate due to the dangers of exposure to pathogenic strains.

## Candidate performance against each criterion

### Criterion A: research question

A good research question (RQ) forms the foundation for a successful essay and in most cases candidates based their work on a clearly formulated, focused question. Many candidates use the RQ as the title of the essay but this is not essential. The research question must also appear in the abstract and in the introduction. In weaker essays the RQ appears after several pages of introduction and literature review. This is problematic as the reader is unable to identify the significance of the information in the introduction or follow a line of argument. Problems also arise when the RQ is presented in different parts of the essay (title, abstract, and introduction) using slightly different wording. This should be avoided.

### Criterion B: introduction

There are three aspects to this criterion: the context, the significance and the worthiness of investigation. In order to reach the top level, all three aspects must be adequately dealt with. In order to demonstrate the biological context and significance of the research question the candidate needs to present a summary of literature and other sources that have been accessed. This aspect of criterion B is often neglected. Weak candidates tend to deal only with “worthiness of investigation” and in doing so tended to refer to personal motivation rather than what the results of the study might reveal about the question being investigated.

### Criterion C: investigation

This criterion covers both data collected from printed sources as well as data collected by the candidate (through experimentation or field work). The way in which this criterion is applied will depend on the style of the essay to some extent (literature based, practically based or a combination of both). Examiners make a judgement about the range and appropriateness of data gathered by the candidate as well as the methods used to gather the data. In addition there must be clear evidence that the investigation has been planned by the candidate. Candidates can achieve this by explaining how information obtained from the sources helped to guide their decisions about which approach to follow. In any case candidates need to justify the approach and not simply report a method. A well planned investigation will not have a predetermined outcome and will be free from bias.

Many biology investigations involve the use of solutions and or other chemicals. In these cases it is important to get the basic chemistry and related calculations right. It is disappointing to see biological investigations undermined by a flawed understanding or flawed computations. Weak investigations often suffer from a poor understanding or application of basic concepts in chemistry such as pH, dilution, concentration and solubility.

### **Criterion D: knowledge and understanding of the topic studied**

There are many ways in which a candidate can display knowledge and understanding of the topic under investigation. This can be done by presenting relevant background information and explaining how this relates to the RQ. Understanding can be demonstrated with reference to the relevant variables that might affect the investigation as well as with reference to the significance of the outcomes. By providing explanations and justifications for their decisions about the research direction (why was something included, why was something else omitted) and methods, a candidate can demonstrate understanding of the research process. Essays that consist mainly of tracts of text taken directly from the sources will fail to convince the examiners that there is in fact an appropriate level of understanding. This also applies to highly technical texts that provide no explanation for terminology.

### **Criterion E: reasoned argument**

Experimentally based essays tend to provide a logically developed and sustained argument. However, many candidates struggle to sustain a line of argument throughout the essay and it can peter out before the conclusion is reached. In order to achieve a more fluent and coherent argument, candidates need to be explicit about their reasoning. In many cases candidates tend to leave it up to the reader to see the significance of the information they are providing or to make the connections between the research question and the conclusions reached. A clear line of argument can be picked up when there is regular reference to the research question throughout the essay and where findings and discussion points are presented in the context of the overall aims of the research.

### **Criterion F: application of analytical and evaluative skills**

The most appropriate approach to analysis depends on the type of data/information collected and presented by the candidate. Essays that are essentially “reports” rather than “investigations” often fail to address this criterion well. The challenge for the candidate is to carry out the analysis in such a way as to address the research question. While candidates should be encouraged to use statistical analysis where appropriate they must also be selective about the techniques used and should be encouraged to explain and justify their approach. Supervisors should note that there is no requirement to include statistical analysis and that the top level can usually be reached without the use of statistical tests.

### **Criterion G: use of language**

There are two aspects to this criterion: the use of clear and precise language on the one hand and the use of terminology appropriate to the topic on the other. Candidates need to adopt and sustain a clear and precise style and show an understanding of and fluency in the main technical terms associated with the topic. There is no requirement to write in the passive voice - the first person singular, active voice, may be clearer and may in fact be easier to sustain (especially for non-native speakers of the target language). In order to reach the higher levels for this criterion the candidate must show an ability to write in a formal style and to accurately use the key terms. Problems arise with very technical investigations where an essay consists largely of descriptions of detailed experimental protocols with little or no attempt to explain the technical language. Such essays often suffer from the fact that the candidate is unable to sustain a consistent linguistic style throughout.

### **Criterion H: conclusion**

In an effective conclusion the candidate restates the research question and outlines the extent to which it has been answered, dealing also with issues that have not been resolved. This sounds straightforward but many candidates struggle to write an effective conclusion. Candidates should express the conclusions concisely and not overstate the findings.

### **Criterion I: formal presentation**

Some weaknesses in presentation skills that were noted in previous sessions are still apparent and these will probably need to be highlighted in every session.

All of the sources accessed must be included in the bibliography. For the majority of the items in the bibliography there should be some in-text reference. Care needs to be taken to provide appropriate and complete bibliographic entries for online sources – simply providing the URL is not sufficient.

Some essays have no obvious structure. This is often reflected in a less than helpful table of contents along the lines of: “introduction”, “body”, and “conclusion”. Headings used in the table of contents should appear in the text of the essay and candidates should carefully check that the page numbers match those in the text. Candidates should be discouraged from using the titles of the internal assessment criteria as chapter headings. Candidates also need to be selective about whether to include an appendix as the essay should make sense without any reference to the appendix. Important information such as the results of statistical analysis should be in the body of the essay. The details of calculations associated with this can be in an appendix (if it is a lot of material). Large tables of raw data can also be presented in an appendix but should be referred to in the text of the essay. If the candidate reports the results of statistical analysis in an appendix but makes no reference to these in the text then the statistics will not be taken into consideration when assessing the essay (since the appendix is not part of the essay).

### **Criterion J: abstract**

Writing the abstract is a technical part of the essay that even good candidates find difficult to do. Apart from careless omissions (no research question, no conclusion), the most common problem is the failure to deal adequately with the scope of the essay. It is expected that the abstract will outline how the research was conducted e.g. the methods that were used, the type and quantity of data that were collected, how test and control groups were selected etc.

### **Criterion K: holistic judgment**

Supervisors should be aware that the comments they write on the extended essay cover sheet (on the circumstances surrounding the research and level of personal involvement of the candidate) can be of considerable assistance to the examiners in assessing criterion K. Note that an essay does not have to show evidence of all of the qualities mentioned in the descriptor and/or guidance notes in order to reach the highest level. The qualities referred to in the stem of criterion K are examples of the type of quality that can be rewarded.

## Recommendations for the supervision of future candidates

Biology continues to be one of the most popular subject choices for the extended essay. Given the demands in terms of equipment, space and time that this involves, supervisors in many schools may be stretched to meet the needs of their students. However effective supervision is a crucial part of the learning process involved in writing the extended essay. Without effective ongoing supervision the process becomes a chore for the candidate and a fruitless exercise in the end. It was clear to examiners that the majority of supervisors had worked hard in guiding and encouraging their students.

The importance of careful supervision and clear guidance to the success of a biology extended essay cannot be overstated. Candidates need guidance at all stages of the process from establishing the RQ to deciding on the best research approach, finding related research materials, establishing a valid argument, deciding on the best analytical approach and dealing with ethical and health issues. Candidates should not be left to their own devices to deal with these issues. In fact these topics should form the basis for the meetings that take place between the candidate and the supervisor.

The most successful essays are those that are based on a small number of a clearly defined and easily manipulated independent variables and a quantifiable and easily measured dependent variable. Successful essays often relied on the use of basic equipment of the type that can be normally found in a school, and were carried out in the school laboratory or in the local environment. In addition, successful essays have a clear academic context and the relevance of published data and or information is explored.

Poor essays are produced when there has not been early intervention by a supervisor. Candidates can be encouraged to engage more fully with the writing process and to communicate more with the supervisor by agreeing on a detailed timetable with internal deadlines for various stages of the research process. This will also help to avoid time being wasted on unsuitable or overambitious investigations.

The number of supervisors who make no comment on the cover sheet has decreased and this is a pleasing development. However other points from previous reports remain valid. Candidates continue to be in need of guidance on the following:

- establishing, refining and using the research question (this is a requirement)
- providing a clear academic context for the research
- sustaining an effective argument
- displaying a command of the language of the topic
- bibliographic entries and in-text references
- structuring the essay (headings and sub headings)
- incorporating and integrating diagrams and illustrations
- selecting material for inclusion in an appendix.

- writing an abstract
- sample size
- statistical approaches
- avoiding bias
- dealing appropriately with ethical issues (related to animal and human subjects).

Finally it must be reiterated that candidates should be discouraged from submitting work which has been conducted as part of a research team at a university or research institute for the extended essay unless it can be shown that the candidate has had a sufficient level of input into the research approach and selection of methodology and sources. “Outsourcing” part of the guidance on the extended essay in this manner might seem like an “easy option” but in fact does not meet the spirit or the intent of the extended essay process and puts the candidate at a disadvantage in the assessment process.