Biology Extended Essay Guide

Overview

An extended essay in biology provides students with an opportunity to apply a range of skills while researching a topic of personal interest in the field of biology. The nature of an extended essay in biology is characterized by a particular biological emphasis within the more general context of a scientific investigation.

Choice of topic

It is important that the extended essay has a clear biological emphasis and is not more closely related to another subject. Biology is the science that deals with living organisms and life processes. A biology extended essay should, therefore, incorporate biological theory and emphasize the essential nature of this subject. Although similar assessment criteria apply to all extended essays in the experimental sciences, for a biology extended essay, the topic chosen must allow an approach that distinctly relates to biology. Where a topic can be approached from different viewpoints, the treatment of the material must be clearly biological. For example, an extended essay in an interdisciplinary area such as biochemistry will, if registered as a biology extended essay, be judged on its biological content, not its chemical content.

Essays that deal with human diseases represent a particular case in point, as these can often be dealt with from a number of perspectives (such as biological, medical, social or economic). In particular, such essays should avoid an overly medical treatment and should focus on biological aspects of the disease rather than on diagnosis and treatment. Some topics are unsuitable for investigation because of ethical issues. Investigations that are based on experiments likely to inflict pain on, or cause unnecessary stress to, living organisms are not appropriate for submission. Investigations that are likely to have a harmful effect on health (for example, culturing micro-organisms at or near body temperature), or those which may involve access to, or publication of, confidential medical information, are also not appropriate.

Some topics may be unsuitable for investigation because of safety issues. Experiments in which the student uses toxic or dangerous chemicals, carcinogenic substances or radioactive materials should be avoided unless adequate safety apparatus and qualified supervision are available. Other topics may be unsuitable because the outcome is already well known and documented in standard textbooks.

The following examples of titles for biology extended essays are intended as guidance only. The pairings illustrate that focused topics (indicated by the first title) should be encouraged rather than broad topics (indicated by the second title).

- "The effect of detergent toxicity on soil bacteria" **is better than** "Detergents in the environment".
- "A study of malnourished children in Indonesia and the extent of their recovery after a period of supervised improved nutrition" **is better than** "Malnutrition in children".
- "A study of the effect of differing pH levels on the growth of *Phaseolus vulgaris*" **is better than** "The effect of acidity on plant growth".
- "The competitive and evolutionary nature of the symbiotic relationship in *Paramecium bursaria*" **is better than** "Symbiosis in animals".
- "The effect of banana peel on seed germination" **is better than** "Factors that affect the germination of seeds".
- "Gel electrophoresis: The construction of an apparatus and the separation of proteins in heat-treated cow's milk" **is better than** "Uses of the gel electrophoresis technique".

The topic chosen for study should be presented in the form of a research question, followed by a statement of intent outlining the research approach to be used in answering the question. In this way, the approach to the topic chosen may be even further clarified. Some examples of this could be the following.

Topic: The distribution and growth of lichens on urban pavements

Research question: How are the distribution and growth of lichens affected by sulfur dioxide and ozone levels in the atmosphere?

Approach: Thalus diameter and population density data is collected from selected sites in different parts of the city. This data is then correlated with published data on the levels of SO2 and O3.

Topic: The effectiveness of commercial antibacterial cleaning agents

Research question: Are commercially available antibacterial cleaning agents effective at controlling the growth of *E. coli* on nutrient agar under laboratory conditions?

Approach: Pure strain *E. coli* are grown on nutrient agar plates under controlled conditions. Filter paper discs soaked in samples of the antibacterial agents are placed on the agar plates and the zone of exclusion is measured and compared.

Topic: Altitude and physical fitness

Research question: Can a programme of training at high altitude have an impact on the fitness of an athlete?

Approach: Using a digital heart-rate monitor, pre- and post-exercise heart rates and recovery times are measured for four athletes. These athletes then carry out a programme of training at 2,500 metres above sea level, after which heart-rate and recovery time data is once again collected. The pre- and post-training data is analysed and compared to published data.

Topic: Urease from soy beans

Research question: Which method of extraction and which temperature conditions give the best levels of urease activity?

Approach: The enzyme is extracted from dried soy beans using three different methods, and the activity of the extract is measured and compared to a standard. Urease activity is measured by noting the time taken for a standard urea solution, with phenolphthaline indicator, to turn pink in the presence of the enzyme extract.

Treatment of the topic

Students should point out early in the essay how the research question was arrived at and, if appropriate, how it was narrowed down, by briefly outlining related aspects that are not being considered in the essay. Students should be encouraged to formulate one or more hypotheses based on the research question. A single well-formulated question may give rise to a small number of precise hypotheses. Essays in biology may be based on data collected by the student through experimentation, survey, microscopic observations, biological drawing, fieldwork or some other appropriate biological approach. Alternatively, essays may be based on data or information obtained from literature, ideally from primary sources, and manipulated or analysed in an original way by the student. Essays that simply restate facts or data taken directly from the sources are of little value. Whichever approach is chosen, the student must ensure that sufficient resources, in the form of data and information, can be obtained in order to allow the topic to be effectively researched.

Essays that involve practical work carried out in the laboratory, or fieldwork, should include a clear and concise description of the experimental procedure. Students should attempt to specify how the research approach and methodology were decided, and show any approaches that were considered and rejected. Ideally, students should carry out the research for the essay solely under the direction of a school supervisor. Some of the best essays have been written by students investigating relatively simple phenomena using standard school apparatus, and this approach is to be encouraged. Regardless of where, or under what circumstances, the research is carried out, students must provide evidence in the essay of their personal contribution to the research approach and to the selection of the methods used. Essays based on research carried out by the student at a research institute or university, under the guidance of an external supervisor, must be accompanied by a covering letter outlining the nature of the supervision and the level of guidance provided.

Generating and presenting data should not be an end in itself; analysis using appropriate scientific techniques is essential. The main body of the essay should consist of an argument or evaluation based on the data or information presented. Here, the student should point out the significance of any graphs, tables or diagrams. Since this is often the longest single section of the essay, it is essential that it is well structured and has an obvious logical progression. A clear structure can be imposed on this section by dividing it into numbered and headed paragraphs. This evaluation should show an understanding of the results and an appreciation of their significance in light of the literature that has been consulted. Students should provide some explanation of anomalies or unexpected outcomes but this should not form a major part of the discussion. If necessary, modifications to hypotheses presented earlier in the essay should be proposed and a research approach for testing these should be suggested. Some assessment of the outcomes of the research in a future or wider context should be made.

Students must be encouraged to undertake a critical evaluation of the work they have done. In this analysis, the student should describe and explain the limitations imposed on the research by factors such as the suitability and reliability of the sources accessed, accuracy and precision of measuring equipment, sample size, validity and reliability of statistics. Biological limitations should be considered, such as those arising from the problem of repeatability and control when using living material, as well as the difficulties of generalizing from research based on a single type of organism or environment.

Interpreting the assessment criteria

Criterion A: research question

In a biology extended essay, the research question is best stated in the form of a question. The research question should not be understood as a statement of the topic but rather as a precisely formulated question that the research will attempt to answer. For example, a statement of the topic of an essay might be “Factors that affect bacterial growth in agar plate cultures”; the research question based on this topic could be “How are the growth rates of three strains of *E. coli* affected by temperature?”. The research question can then be used to formulate a hypothesis, or hypotheses, which can be tested. The research question should be identified clearly and set out prominently in the introduction. A broad statement of the topic of

the essay or a statement of the hypothesis is **not sufficient** on its own to meet the requirement for a research question in a biology extended essay.

Criterion B: introduction
The purpose of the introduction is to set the research question into context. It is usually appropriate to include the general background biological theory required to understand how the research question has arisen. Students are not expected to explain basic biology forming part of the Diploma Programme biology course, but they are expected to be able to show that they fully understand it and can apply it correctly. Some research questions may require background from other disciplines. This should be kept to a minimum, as the essay will be judged on its biological content.

Criterion C: investigation
The way in which the investigation is written will depend very much on whether or not the essay is based on experimental work performed by the student. For essays that are based on data taken from written sources, the student should explain clearly how the data has been selected and should comment on its reliability. For experimental work, sufficient information on the methodology should be provided to allow the work to be repeated. Students should demonstrate that they understand the theory behind any techniques or apparatus used. They are also expected to show an awareness of any limitations or uncertainties inherent in their techniques and apparatus.

Criterion D: knowledge and understanding of the topic studied
A biology extended essay should be based on specific, relevant and clearly defined aspects of the biological study of living organisms. The information and ideas should be presented in a way that provides evidence that these have been understood and applied correctly. Material extracted from the sources should be referenced and incorporated into the main body of the essay in a way that demonstrates the student's understanding.

Criterion E: reasoned argument
Because of the nature of the subject, students writing a biology extended essay must make a special effort to maintain a reasoned, logical argument that focuses on the research question. Essays that attempt to deal with a large number of variables are unlikely to be focused and coherent. A clear and logical argument can be achieved by making repeated reference to the research question and to the hypotheses derived from it. An assessment of the extent to which the hypotheses are supported, or the question is answered, by the data or information accessed should form part of the argument.

Criterion F: application of analytical and evaluative skills appropriate to the subject
The stated conclusion(s) must be based on the data, information and/or evidence presented in the essay. The data must be analysed and presented in such a way that the argument leading to the conclusion is supported and clarified. Tables of raw data will generally not achieve this on their own. Raw data must be analysed, processed and presented in a way that relates clearly and directly to the central argument of the essay. Where appropriate, this analysis should allow for an assessment of the validity of the hypothesis. Errors and uncertainties arising from the methodology, instruments and/or techniques should be analysed and critically evaluated.

Criterion G: use of language appropriate to the subject
Students writing in biology need to show a mastery of, and fluency in, the use of appropriate terminology. At the same time, students need to avoid excessive use of jargon. Any technical terms that are used should be explained and the student must demonstrate an understanding of these terms by using them appropriately within the text. The student must try to maintain a consistent linguistic style throughout the essay.

Criterion H: conclusion
The conclusion should relate directly to the research question and should point out the main findings of the research. Biological research often reveals unexpected outcomes and these should be pointed out, even if they were not part of the original plan. The original research question may not be fully answered by the investigation. In these cases, the student should point out unresolved issues and make suggestions as to how these might be further investigated.

Criterion I: formal presentation
Biological investigations often require the support of referenced material, not only in the form of text or data, but also as diagrams or drawings. Care must be taken to supply references for illustrations taken from sources. Students must avoid the temptation to supply illustrations for their own sake. Illustrative material should only be included if it enhances the argument or supplies information that cannot be easily provided in another way. Original photographs, photocopies or downloaded images that are not labelled or put into the context of the investigation are unlikely to enhance the essay.

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Biological investigations often result in large quantities of raw data. Large tables of raw data are best included in an appendix. Processed data that is central to the argument of the essay should be included in the body of the essay, as close as possible to its first reference.

Criterion J: abstract

For a biological investigation, the abstract must include the research question and a conclusion that directly relates to the research question. In addition, the description of how the research was conducted must include a description of the methodology and the scope of the study.

Criterion K: holistic judgment

Qualities that are rewarded under this criterion include the following.

- Intellectual initiative: Ways of demonstrating this in biology essays include the choice of topic and research question, and the use of novel or innovative approaches to address the research question.
- Insight and depth of understanding: These are most likely to be demonstrated as a consequence of detailed research and thorough reflection, and by well-informed and reasoned argument that consistently and effectively addresses the research question.
- Originality and creativity: These will be apparent by clear evidence of a personal approach backed up by solid research and reasoning.