

SUBJECT AREA: BIOLOGY

Biology is the study of living organisms. So an extended essay in biology should focus on some aspect of a living organism within a more general set of scientific criteria.

The examiner will look for you to be playing the role of a scientist as you present your research. Performing an actual experiment is highly recommended by IBO, though not required for the subject area of Biology. Whether or not you do an experiment, the scientific process should be the basis of the structure of your essay. Before deciding on Biology as your subject area, review the steps involved in the “scientific method” of research with a mentor in the field of biology.

The following things should be included in your biology extended essay:

Presenting a research question worthy of study
Forming multiple hypotheses, considering alternatives,
Gathering, measuring, recording and analyzing data,
Evaluating data and procedure
Proposing revisions to your procedure for future research

You will be graded on your ability to show the following four things :

1. Biological study of living organisms:

With reference to this, your emphasis should be on the biological content throughout your essay.

2. Use of methods and resources:

Involving your ability to choose appropriate resources and methods relevant to biology, and your ability to use these resources and methods competently and to show your personal involvement with the research.

3. Analysis of the limitations surrounding the research:

Regarding your ability to analyze limitations in your sources, and research procedure.

Choosing your topic:

The IB manual reminds us that Biology is not an easy option for your extended essay. Only candidates who are genuinely interested in the subject matter should choose this field of study. IBO warns that there are several dangers in doing an extended essay in biology which can result in an unsuccessful score:

1. You may select a topic which extends to some subject area closely related to biology- such as biochemistry. According to IB guidelines, the material included in your essay will be judged only on its biological content, not on its chemical content. Content other than biology could be wasted.
2. Similarly, it may be tempting to approach a topic relating to human diseases, which can be discussed from a number of perspectives: medical, social, economic, and biological, etc. IBO warns that should you choose to research some human disease, be careful to avoid stressing the diagnosis or medical treatment of the disease. Focus instead on the biological process, cause and progression of the disease relative to life processes, not on its ramifications for society as a whole.
3. Consider other dangers when choosing a topic in the field of biology. Some issues become unsuitable for ethical reasons. For example, experiments that inflict pain on living organisms or have a harmful effect on health in general should be avoided.
4. Some experiments may also depend on access to or publication of confidential medical information. Since access to such information is usually denied, such experiments could result in a lack of sufficient support for material presented and therefore should be avoided.

5. In addition, avoid experiments that involve hazards to safety. When working with toxic chemicals or electrical processes, for instance, do so only under the supervision of a qualified adult-- preferably here on our school campus.

6. Biological concepts, terms, processes, and theory should be emphasized throughout your essay.

Examples of topics used in previous essays:

- * The ozone hole-- UV radiation and its effect on the growth of *Lepidium sativum*.*
- * The effect of detergent toxicity on certain bacterial strains*
- * The study of the effect of differing pH levels on the growth of *Phaseolus vulgaris**
- * The effect of banana peel on seed germination*
- * A study of malnourished children in Indonesia and the extent of their recovery after a period of supervised improved nutrition.*
- * Dioxins in the Environment: An investigation of the impact of Dioxins on wild life, focusing on the Great Blue Heron colonies of the Strait of Georgia*
- * The comparison of effectiveness of four commercial brands of household cleaners: Comet, Dettol, Pine Sol, and Scope in their antibacterial influence on *Esherchia Coli**
- * Nutrition in goldfish: Affects of the form of feed and environmental factors on the nutrient requirements of goldfish*
- * Effects of magnetic field on germination and growth of corn seeds*
- * The influence of antibiotics on cell wall synthesis and protein synthesis in bacteria*

Range and variety of Sources: Use as many different types of sources as possible. Such as:

Scholarly journals	Documents	Government records
Interviews	Films & T.V.	Speeches & lectures
Magazines	Newspapers	Photographs
Books	Displays	Online sources

Include both **primary** and **secondary** sources.

A **primary source** would be the raw data from your experiment.

A **secondary source** would be any other studies you encounter from reference materials you consult which are similar to the experiment you plan to conduct and which could support or refute the findings you derive from your investigation.

In addition: It might be well to bear this in mind:

IBO warns us to use **online sources** sparingly. Though the Internet may seem more convenient, IBO stresses the importance of being careful about the quality of information found there. Frequently this information lacks accuracy, authenticity and reliability. Also occasional piracy exists in some websites. This could put your diploma at risk for malpractice penalties. Unless you are prepared to question and evaluate ideas found on the web as you present them in your essay, it is wise to stick with printed materials which respect copyrights and which have been examined for accuracy.

Treatment of Topic:

Essays on biology may be based on data collected through:

- * **Experimentation**-- Conducting an actual experiment in a laboratory.
- * **Survey**-- Performing a series of interviews in your local town or county, to investigate a local issue.
- * **Microscopic observations**-- Investigating an issue by observing a process or situation through a microscope.
- * **Biological drawings**-- Observing phenomena, or reporting data by creating a series of drawings as illustrations for your text. These could result from your own study or a study conducted by another group.
- * **Field work**, or any other appropriate form of biological research

Whatever approach you select, IBO urges that you base your data on sufficient resources. IB guidelines allow for data obtained from literature-- ideally from primary sources. (Scientific studies reported in scholarly journals) However, these data should be manipulated or analyzed in an original way. The IB manual maintains that essays which simply restate facts or data taken directly from sources are of little value, and usually result in unsuccessful scores. Remember, your extended essay is basically a research project... not a factual report!

Regardless of where, or under what circumstances your research is carried out, IB reminds us that candidates must provide evidence in the essay of their personal contribution to the research and to the approach and selection of methods used. This is why performing physical experiments, though not required, actually makes an essay on biology easier to write.

Essays which involve practical work carried out in a laboratory or field work should include a clear and concise description of the experimental procedure, specifying how the research approach and methodology were devised and any related approaches that were considered and rejected.

Generating and presenting data should not be an end in itself. Analyze this information using appropriate scientific techniques. IBO reminds us that the main body of the essay should consist of an argument or evaluation of the procedure used to conduct the research. This analysis of your own work should include a thorough explanation of the significance of graphs, tables, or diagrams, including any other possible interpretations of the results shown. Also, you should discuss the limitations imposed on the research by factors such as suitability and reliability of sources, accuracy and precision of measuring equipment arising from the problem of repeatability and control when using living material, as well as difficulties of generalizing from research based on a single type of organism or environment.

The IB manual also urges candidates to provide some explanations of anomalies, or unexpected outcomes encountered in the process of the research. In this way modifications to the original hypotheses could be proposed and a revised research approach for testing these ideas out could be suggested.

IB recommends that to clarify the structure of the essay, the material be divided and presented under a series of subheadings... even perhaps containing numbered paragraphs.

The following are some examples of titles, research questions, and approaches to a topic that have been used in the past:

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

Title: 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 to topic: 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 arag plates and the zone of excusion is measured and compared.

Title: Altitude and physical fitness

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

Approach to topic: 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 program 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 analyzed and compared to published data.

Title: Urease from soy beans

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

Approach to topic: 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.

FOLLOWING IS A LIST OF ASSESSMENT CRITERIA RELATIVE TO THE BIOLOGY EXTENDED ESSAY:

CRITERIA A: The research question

The research question should not be thought of as a statement of the topic of the essay but rather as a precisely formulated question that the research will attempt to answer. For example The topic statement: "Factors that affect bacterial growth in agar plate cultures" becomes the question, "How are the growth rates of three strains of E. coli affected by temperature?" The question can then be used to formulate the hypothesis, or guess as to what would be the answer to the above question. The question itself should be identified clearly in the introduction.

CRITERIA B: The introduction

The purpose of the introduction is to set forth the research question. 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 as learned in your IB class. Yet you will be expected to show that you fully understand it and can apply it correctly to your chosen topic. Some research questions may require background from other disciplines. However any information not considered "biology" should be kept to a minimum, as the essay will be judged on its biological content only.

CRITERIA C: The 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 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 or apparatus used.

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. All cited material should be used to support the student's own argument and not to substitute for it. A statement made by a scientific expert should be challenged wherever there is evidence to do so. All material used from sources must be acknowledged in references. If students make use of internet-based sources, they should do so critically demonstrating a full awareness of the source's potential unreliability.

CRITERIA D: Knowledge and understanding of the topic studied

A biology extended essay should be based on specific, relevant and clearly defined aspect 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.

CRITERIA E: The 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 or 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.

CRITERIA 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 analyzed 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 analyzed, 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 methodology, instruments and/or techniques used should be analyzed and critically evaluated.

CRITERIA 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.

CRITERIA H: The 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 for some essays, 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 such a case, the student should point out unresolved issues and make suggestions as to how these might be further investigated.

CRITERIA I: The 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 include 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 context of the investigation are unlikely to enhance the essay.

Biological investigations often result in large quantities of raw data. Large tables of raw data are best included in an appendix. If an appendix is included, it should be cross-referenced with the essay, otherwise it has little value.

CRITERIA J: The 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.

CRITERIA K: Holistic judgement

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.

Incite and depth of understanding: These are most likely to be demonstrated as a consequence of detailed research, reflection that is thorough and 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.

Problems demonstrated by students in past essays:

Following are problems reported by examiners relative to several important areas with respect to the Biology extended essay--

Biological study of living organisms:

Expectations: The extent that your essay is exclusively concerned with aspects of this biological study of living organisms that are specific, relevant to biology and clearly defined.

Problems in the past:

Though most essays submitted have dealt with biological topics, diagnosis and treatment of human diseases continues to be a problem. Such essays rarely scored well on this criterion because of lack of emphasis on biological content.

Use of methods and resources:

Expectations: The extent to which you choose methods and sources that are appropriate to biology and use them competently; the extent to which these methods and sources are relevant to your research question; and the extent to which you show evidence that you have been personally involved in the application of these methods and sources.

Problems in the past:

Candidates have not been careful to point out principles underlying their research approach and techniques used. They often do not explain and justify their techniques, nor do they say why alternative approaches were not used--especially when they report experiments conducted on university levels. Such omissions furnish evidence that these candidates have had no personal involvement in the research they have presented.

Analysis of the limitations surrounding the research:

Expectations: The extent to which you show awareness of ways in which your study may have been limited; the extent to which you analyse uncertainties, approximations, quality of your research methods, and quality of sources used; and the extent to which your explanations, confirmations, and refutations are supported by your analysis.

Problems in the past:

This continues to be the most difficult of the biology subject matter criteria. In the past few candidates critically evaluated their own work. Even fewer commented on the validity or quality of the sources they used.

In conclusion:

When choosing topics for extended essays in Biology, candidates should be aware of the need to select a topic which is suitable for a "practically based" essay and to ask themselves the following questions: Do I have sufficient knowledge to relate my findings to appropriate biological theories? Are sufficient materials and resources available to me? Can adequate research be done in the time allowed?

Biology is a subject area which requires a formal approach, a clear structure and a particular style of argument. An efficient research question must be formulated which can lead to an appropriate hypothesis or set of hypotheses. An adequate research approach and/or experimental design should be accessible which can yield relevant data to test the hypotheses proposed. Candidates must be skilled enough in science to critically evaluate their research process and suggest logical modifications which are meaningful in a scientific context.

Biology may present a particular challenge-- but for a candidate, truly skilled in this area and willing to accept the problems involved, an essay in this field can result a satisfying feeling of accomplishment.