

## Science Extended Essay Guide

Revised October 22, 2009

If you have chosen to do an extended essay in the experimental science (Group 4), it is likely that you are planning to study science at university. Doing your EE in biology, chemistry, or physics will help you when it comes to writing lab reports for demanding university TA's, who are generally graduate students working on a thesis of some kind.

Your EE in a Group 4 subject should look like a very long lab report or submission to a scientific journal. **Your investigation must include analysis of data:**

- data collected in an experiment you perform, either at school or at home
- data collected and published by a scientist at a university or elsewhere, that you *examine in a different way* (i.e. you are not just reporting on someone else's results)
- data collected from an online database such as ALFRED (<http://alfred.med.yale.edu/>), PubMed (<http://www.ncbi.nlm.nih.gov/pubmed/>) or OMIM (<http://www.ncbi.nlm.nih.gov/sites/entrez?db=OMIM>)

A relatively simple experiment could give you a higher end result than a more complex literature-based essay, where you would be using data collected by persons other than yourself. Experiments with commonly known results or that you did in class are unacceptable for an extended essay investigation.

If you choose to do a literature-based essay, you will be required to present and discuss data and put it into a new context or interpretation. It is not sufficient to do a summary essay based on what you have read – there **must** be analysis and interpretation that is yours and yours alone.

When choosing your topic, please ensure that it fits specifically within Biology, Chemistry or Physics. Many students start out with topics that are in-between subject areas (such as Biochemistry or Medicine) and are inappropriate for an EE in Science. Check the current EE guide to be sure.

In addition to the data you will be analysing, you will require relevant background information, for which you will need to consult scientific journals – the information in your textbook is not always sufficient for depth of information. Examples include:

- Journal of Applied Polymer Science
- Journal of Cell Biology
- American Journal of Physics

Note – many journals have their abstracts available online, but to access the whole article, you need to pay a fee or be a member. University libraries will have many scientific journals available, and you may copy entire articles to take home with you. Please note, an article on a science topic that appears in Time, Maclean's or another magazine is usually insufficient in its depth of treatment of the topic – it is written by a science reporter using information from journals or interviews with scientists.

### General Guidance

When writing, consider your audience. Academic writing such as an extended essay requires more formal English than a letter, email, or creative piece. Avoid colloquialisms and contractions and don't add words just to increase your word count. The best extended essays are between 3000 and 3500 words in length.

It is a good idea to read your essay out loud: if it sounds like the way you would normally talk to your friends, it is probably too informal. There are several good style guides to help you with grammar and sentence structure. (Strunk's Elements of Style is an excellent reference, available at <http://www.bartleby.com/141/>.)

The following headings should be used to organize your essay:

1. Introduction – this should be the last section of your essay that gets written. It must include the following sub-headings:
  - a) Research Question should very early in the introduction. Your extended essay mentor can help you design a good research question.
  - b) Hypothesis and Explanation of Hypothesis which detail both your prediction about the outcome of your experiment and an explanation, based on theory (citations are a must here), which supports your hypothesis.
  - c) Variables, which should be identified as follows:
    - Dependent – what you measured in your experiment(s)
    - Controlled
      - Independent – what you manipulated, or controlled over a range of values
      - Fixed – what you kept constant
    - Uncontrolled – not always discussed, but if there were factors beyond your control that had an effect on your results, list them here

In addition, your introduction must include relevant background information. Keep in mind that the examiners are IB teachers from your chosen subject area, so it is not necessary to be overly simplistic here.

2. Materials and Methods – this should be written in paragraph form. If you feel the need to include the minute details of your experiment (i.e. if you refer to specific steps in your error analysis, for example) it may be included as an appendix. This section is written in past tense, since you have already completed your experiment when you are writing your essay.
3. Data Collection – includes your observations in words, tables and graphs.
  - a) Relevant qualitative observations
  - b) Summary data tables (again, raw data could be included in an appendix if necessary) which include some descriptive statistics such as means and standard deviations.
  - c) Graphs are often a good way to show trends in your data, and are most useful included within the body of your essay.
4. Analysis of Data – includes calculations such as rate of reaction, and analytical statistics such as a T-test or ANOVA.
  - Check out Merlin, an add-in for MS-Excel which not only expands the range of graphs you can make, but can tell you what type of statistical test you should do for the type of data you collected, and has built-in functions that will do the statistical test for you. It is available at <http://www.heckgrammar.kirklees.sch.uk/index.php?p=10310>. (FREE!)
5. Discussion – this is where you discuss whether or not your experiment has answered your research question. Error analysis, extensions to the investigation and unanswered questions are also included in this section.
6. Conclusion – in one to two paragraphs, conclude your essay with what was learned during the investigation. It should refer back directly to the research question, and whether or not the hypothesis was correct. Sources of error may be reiterated here (briefly).
7. Appendices – if necessary, this is where you include the details of your experimental protocol and raw data. This is only necessary if you specifically refer to them in your essay (i.e. in the discussion). Keep in mind that examiners are not required to look at your appendices, so if you really need them to see something (like a graph) it is probably best to include it within the body of your essay.
8. Works Cited – this is not a “Bibliography” of all the books, journals and websites you consulted while writing your EE. Only list those works you specifically cited in your essay. Follow the CSE format. (See <http://library.osu.edu/sites/guides/cse/d.php> for details.)