**Chapter No 14**

**Academic Writing**

**What is academic writing?**

Academic writing is about an academic topic at an academic level, this means first of all that you write having specific goals in mind so you know what you want to achieve. It also mean that you know who your readers are? What there knowledge level is? and what there expectation of the text are. As a writer you can anticipate this.

Academic writing does many of the things that personal writing does not: it has its own set of rules and practices

Academic writing follows a particular ‘tone’ and adheres to traditional conventions of punctuation, grammar, and spelling

There are two key elements in academic writing which are appended below.

**1- Natural Sciences**

**2-Social Sciences**

**Natural Sciences**

**Definition:** Natural sciences are the disciplines that study objects or processes of the physical nature by means of scientific methods, i.e. Physics, Chemistry, and Biology.

**Social Sciences**

**Definition:** Social science deals with human society, social groups, and individuals in their social relationship, institutions of society, as well as material and cultural goods as expression of the coexistence of human being, i.e. Economics, Sociology and Politics.

**Difference between Natural & Social Sciences**

|  |  |  |
| --- | --- | --- |
| Differential points | Natural Sciences | Social Sciences |
| Ontological Approach | Discovering Natural Laws of phenomena in the physical world. | Understanding the social aspects in human interaction. |
| Epistemological Approach | Analytic  | Synthetic |
|  | single elements◊Complex system | complex system◊Individuals |
| Object of study | Nature | Social actors |
| Methodological Approaches | Inductive generation of theories | Inductive generation of theories |
|  | Empirical testing mainly quantitatively | Empirical testing qualitatively and quantitatively |
| Scientific outcome | Fallible and infallible theories | Fallible and infallible theories |
|  | Gradual improvements of formalism | Heuristics |
|  | Stepwise evolution of world views |  |

**Writing in the Social Sciences**

Although there may be some differences in writing expectations between disciplines, all writers of scholarly material are required to follow basic writing standards such as writing clear, concise, and grammatically correct sentences; using proper punctuation; and, in all Walden programs, using APA style. When writing in the social sciences, however, students must also be familiar with the goals of the discipline as these inform the discipline’s writing expectations. According to Ragin (1994), the primary goal of social science research is “identifying order in the complexity of social life. Serving the primary goal are the following secondary goals:

 1. Identifying general patterns and relationships

2. Testing and refining theories

3. Making predictions

 4. Interpreting culturally and historically significant phenomena

5. Exploring diversity

6. Giving voice

7. Advancing new theories

 To accomplish these goals, social scientists examine and explain the behaviour of individuals, systems, cultures, communities, and so on, with the hope of adding to the world’s knowledge of a particular issue. Students in the social sciences should have these goals at the back of their minds when choosing a research topic or crafting an effective research question. Instead of simply restating what is already known, students must think in terms of how they can take a topic a step further. The elements that follow are meant to give students an idea of what is expected of social science writers.

 **Main Idea**: Because one cannot say everything there is to say about a particular subject, writers in the social sciences present their work from a particular perspective. For instance, one might choose to examine the problem of childhood obesity from a psychological perspective versus a social or environmental perspective. One’s particular contribution, proposition, or argument is commonly referred to as the thesis and, according to Gerring, Yesnowitz, and Bird (2004), a good thesis is one that is “new, true, and significant. To strengthen their theses, social scientists might consider presenting an argument that goes against what is currently accepted within that field while carefully addressing counterarguments, and adequately explaining why the issue under consideration matters. For instance, one might interpret a claim made by a classical theorist differently from the manner in which it is commonly interpreted and expound on the implications of the new interpretation. The thesis is particularly important because readers want to know whether the writer has something new or significant to say about a given topic. Thus, as you review the literature, before writing, it is important to find gaps and creative linkages between ideas with the goal of contributing something worthwhile to an ongoing discussion. In crafting an argument, you must remember that social scientists place a premium on ideas that are well reasoned and based on evidence. For a contribution to be worthwhile you must read the literature carefully and without bias; doing this will enable you to identify some of the subtle differences in the viewpoints presented by different authors and help you to better identify the gaps in the literature. Because the thesis is essentially the heart of your discussion, it must be argued objectively and persuasively.

 **Method**: In examining a research question, social scientists may present a hypothesis and they may choose to use either qualitative or quantitative methods of inquiry or both. The methods most often used include interviews, case studies, observations, surveys, and so on. The nature of the study should dictate the chosen method. (Do keep in mind that not all your papers will require that you employ the various methods of social science research; many will simply require that you analyze an issue and present a well reasoned argument.) When you write your capstones, however, you will be required to come to terms with the reliability of the methods you choose, the validity of your research questions, and ethical considerations. You will also be required to defend each one of these components. The research process as a whole may include the following: formulation of research question, sampling and measurement, research design, and analysis and recommendations. Keep in mind that your method will have an impact on the credibility of your work, so it is important that your methods are rigorous. Walden offers a series of research methods courses to help students become familiar with research methods in the social sciences.

 **Organization**: The APA manual provides a useful outline of how a social science paper is to be organized. Do keep in mind that you may not need to use this format for every paper you submit at Walden. Research papers that follow the APA style are divided into the following sections: **title, abstract, introduction, literature review, method, results, discussion, references, and appendices**. Note that the presentation follows a certain logic: in the introduction one presents the issue under consideration; in the literature review, one presents what is already known about the topic (thus providing a context for the discussion), identifies gaps, and presents one’s approach; in the methods section, one identifies the method used to gather data; in the results and discussion sections, one then presents and explains the results in an objective manner, acknowledging the limitations of the study. One may end with a presentation of the implications of the study and areas upon which other researchers might focus.

 **Objectivity**: Although social scientists continue to debate whether objectivity is achievable in the social sciences and whether theories really represent objective scientific analyses, they agree that one’s work must be presented as objectively as possible. This does not mean that writers cannot be passionate about their subject; it simply means that social scientists are to think of themselves primarily as observers and they must try to present their findings in a neutral manner, avoiding biases, and acknowledging opposing viewpoints.

 **Language:** It is important to note that instructors expect social science students to master the content of the discipline and to be able to use discipline appropriate language in their writing. Successful writers of social science literature have cultivated the thinking skills that are useful in their discipline and are able to communicate professionally, integrating and incorporating the language of their field as appropriate. For instance, if one were writing about how aid impacts the development of less developed countries, it would be important to know and understand the different ways in which aid is defined within the field of development studies. If you have content-specific questions, be sure to ask your instructor. The Writing Center is available to help you present your ideas as effectively as possible.

**Writing in the Natural Sciences**

“An effective voice in a scientific paper is a little likes an effective umpire or referee in a sports contest – the less the audience is aware of the referee, or the personal voice of the scientist, the better.”

- Tradition and Adaptation (123)

**Basic Purpose/Approach**: Natural scientists may be writing to describe observations and draw conclusions from them or they may be writing to survey a broader array of observations in the field and from these, draw conclusions. Because their audiences are very specialized, scientists know them precisely, and are often personally familiar with a number of the individuals who will be most likely to read their work. Scientific writers tend to assume humble personae. For these reasons, the personal voice is not considered necessary or desirable and diction is highly specialized.

Significantly, scientists write with an awareness of audience and purpose just as writers in other disciplines do – they are not writing in the fashion they do because they are actually entirely objective, but rather because various habits of thought and requirements of disciplinary expectation require them to write as if they are entirely objective.

**Nouns:** Scientists tend to string long noun phrases together in order to accurately identify complicated phenomena and objects. However, because of this need to be as specific and accurate as possible, scientific writers often struggle with misplaced modifiers. Proper punctuation and parallelism are frequent solutions used to solve this problem.

**Pronouns:** On the rare occasions when scientists use a first-person pronoun, they prefer the plural “we.” Research in the natural sciences is more often collaborative than in other disciplines, so the use of “we” places emphasis on the collaborative nature of the research and the research itself, rather than on the individuals involved in the research. Even in scientific book reviews in which one might suppose writers would occasionally use “I,” scientists tend to prefer “we” as indicative of themselves and the larger scientific community/audience.

**Titles:** Lengthy, specific titles are considered desirable in the natural sciences, because audiences are typically specialized and seeking primary knowledge from which to draw larger conclusions.

Tense:

Scientists place a high value on accepted work and so they use the present tense in referring to accepted theories and facts. Conclusions that are not yet accepted or the work that led to conclusions – even validated ones – do not deserve the status of fact and are thus referred to in the past tense.

Present:

* Refers to published work. Newton’s laws are…

Past:

* Refers to one’s own work which, of course at the time of writing, has not yet been published and incorporated into the body of presently accepted work.
* Refers to work (not conclusions) of others. Newton calculated…

**Passive Voice:** Because of the de-personalized nature of scientific writing, frequent use of the passive construction is a marker of scientific writing. Passive voice is particularly prominent in the Methods sections of scientific articles, because the goal in this section is to enable others to replicate the experiment, not to emphasize the original experimenters.

**Note:** the subjects of studies are more often partnered with active verbs. For example:

The flowers wilted when…

**Modifiers:** Many modifiers used in scientific writing are themselves nouns, but scientists use modifiers not only in the interest of being specific, but in order to qualify their assertions. Rather than stating that a finding is “exceptional,” a scientist might qualify the statement by noting that the finding is “markedly different from the expected results.”

**Diction:** As noted above, scientists value specific, clear language, so technical jargon and precise linguistic choices are a must. A catchy style and accessibility to a lay audience are not factors in diction choices. Rather, scientists want other scientists to be able to understand and locate their work as conveniently as possible.

**Tone:** Scientists work to establish new and unique findings in relation to a body of already established knowledge. They write to contextualize their own work within that of the broader community, so novelty and originality are de-emphasized in order to establish the ways in which new findings extend or modify previous ones.

**Types of Writing in the Social and Natural Sciences**

**Writing in the Natural Sciences*:*** In this course, students will write several types of scientific documents common in the natural science disciplines (Chemistry, Biology, Physics, etc.), such as lab reports, journal articles, and grant proposals, along with articles that interpret a scientific issue for the general public. Improving the clarity of their writing will help students throughout their academic careers, whether or not they ultimately enter scientific fields.

**Writing in the Social Sciences:** A course designed specifically for students majoring in fields such as Psychology, Sociology, Anthropology, Economics, Political Science, or Education. Students will be introduced to several different disciplines within the Social Sciences and study their predominant methods of inquiry. Most disciplines in the Social Sciences focus on the systematic study of human behaviour. Students will learn about methods of research, the types of evidence that are valued, and how to write to communicate effectively in the Social Sciences.

**Natural science** is a branch of [science](https://en.wikipedia.org/wiki/Science) concerned with the description, prediction, and understanding of natural phenomena, based on observational and [empirical evidence](https://en.wikipedia.org/wiki/Empirical_evidence).

Below are the main types of natural sciences

###  Biology:

This field encompasses a set of disciplines that examines phenomena related to living organisms.

 Biology is concerned with the characteristics, [classification](https://en.wikipedia.org/wiki/Scientific_classification) and [behaviors](https://en.wikipedia.org/wiki/Behaviors%22%20%5Co%20%22Behaviors) of [organisms](https://en.wikipedia.org/wiki/Organism), as well as how [species](https://en.wikipedia.org/wiki/Species) were formed and their interactions with each other and the [environment](https://en.wikipedia.org/wiki/Environment_%28biophysical%29).

###  Chemistry:

Constituting the scientific study of matter at the [atomic](https://en.wikipedia.org/wiki/Atom) and [molecular](https://en.wikipedia.org/wiki/Molecule) scale, chemistry deals primarily with collections of atoms, such as [gases](https://en.wikipedia.org/wiki/Gas), molecules, [crystals](https://en.wikipedia.org/wiki/Crystal), and [metals](https://en.wikipedia.org/wiki/Metal).

###  Physics:

Physics embodies the study of the fundamental constituents of the [universe](https://en.wikipedia.org/wiki/Universe), the [forces](https://en.wikipedia.org/wiki/Forces) and interactions they exert on one another, and the results produced by these interactions.

In general, physics is regarded as the fundamental science, because all other natural sciences use and obey the principles and laws set down by the field.

####  Astronomy:

This discipline is the science of [celestial objects](https://en.wikipedia.org/wiki/Astronomical_object) and [phenomena](https://en.wikipedia.org/wiki/Phenomenon) that originate outside the [Earth's atmosphere](https://en.wikipedia.org/wiki/Atmosphere_of_Earth). Astronomy includes the examination, study and modelling of [stars](https://en.wikipedia.org/wiki/Star), [planets](https://en.wikipedia.org/wiki/Planet), [comets](https://en.wikipedia.org/wiki/Comet), [galaxies](https://en.wikipedia.org/wiki/Galaxy) and the [cosmos](https://en.wikipedia.org/wiki/Cosmos).

###  Earth science:

Earth science (also known as geosciences), is an all-embracing term for the sciences related to the planet [Earth](https://en.wikipedia.org/wiki/Earth_%28planet%29), including [geology](https://en.wikipedia.org/wiki/Geology), [geophysics](https://en.wikipedia.org/wiki/Geophysics), [hydrology](https://en.wikipedia.org/wiki/Hydrology), [meteorology](https://en.wikipedia.org/wiki/Meteorology), [physical geography](https://en.wikipedia.org/wiki/Physical_geography), [oceanography](https://en.wikipedia.org/wiki/Oceanography), and [soil science](https://en.wikipedia.org/wiki/Soil_science).

**Types of Social Sciences:**

Below are the different types of social sciences

 **Anthropology:**

Anthropology is a social science, which includes several different aspects like archeology, physical or biological anthropology, archeology, ethnography, anthropological linguistics and also ethnography. anthropology is based on four fundamental branches or pillars of anthropology, which are physical anthropology, socio-cultural anthropology, linguistic anthropology, and archeology.
 **Economics:**

Economics is a branch of social sciences that aims to study the production, distribution, and consumption of wealth. Economics is further categorized into two broad divisions, which are microeconomics and macroeconomics
 **History:**

History is a discipline of science, which deals with the study of the human race in previous times, with regard to scientific discoveries, important events, documented findings, and archaeological evidence.
 **Communication:**

If it hadn't been for communication, humans wouldn't have evolved beyond a certain time. The study of communication is also included under the umbrella of social sciences.
Communication is thus a very important aspect of our everyday lives, especially in relation to body language.
 **Education:**

The field of education includes teaching and learning specific skills, but more importantly it involves mastering the art of disseminating knowledge, balanced judgment and creating responsible citizens through the process of all-round education.
 **Psychology:**

The branch that deals with the study of the human mind - psychology. It helps determine how humans react and adapt to life's various events, why marriages fail, why some children grow up into monstrous murderers, or how mentally sick patients in the psychological sense, do what they do.

 **Political Science:**

Political science has been one of the major subjects under the branch of social sciences. Political science is the discipline that studies the theories and practice of politics.
 **Geography:**

Geography is classified into two different disciplines - human and physical geography. Human geography deals with how space is created, viewed and managed by human beings. While physical geography focuses on the natural environment which includes climate, vegetation, life, soil, water and even landforms.
 **Law:**

Law is one of the important branches of social sciences. The study of law deals with the study of law structures and implied legal policies. It also incorporates case studies in the past and social patterns for the possibilities of formulation of new laws.
 **Linguistics:**

Linguistics is a branch of social sciences that deals with cognitive and social aspects of human languages. Conventionally, linguistics is divided into four major areas, which are syntax, semantics, phonetics and phonology.
 **Social Work:**

Social work is an active area of social science where it is a professional area of being of service to the unfortunate and afflicted. It reins in community cooperation to help out those in need.
 **Sociology:**

Sociology can be defined as the study of societies and human social behavior. Sociology generally includes social rules and processes and in-depth analysis of social interactions

**Abstract writing**

How to write an abstract?

If you need to write an abstract for an academic or scientific paper, don't panic! Your abstract is simply a short, standalone summary of the work or paper that others can use as an overview.[[1]](http://www.wikihow.com/Write-an-Abstract#_note-1) An abstract describes what you do in your essay, whether it’s a scientific experiment or a literary analysis paper. It will help your reader to understand the paper and it will help people searching for a particular work to find it and decide whether it suits their purposes. Seeing as an abstract is only a summary of the work you've already done, it's easy to accomplish

**Writing Informative Report**

This report type is common in many organizations. They serve two purposes:

1. Provide a record of accomplishments (individual, department, organization)

2. Share information on projects between employees or departments. Because they are common, many organizations have these reports in templates

**Four Types of Informative Reports**

 **1. Activity Reports** Written and shared at set periods to share information on tasks, activities, and projects includes accomplishments. Often read by supervisors.

 **2. Progress Reports** Written to show progress on a project (for supervisors and clients). These are mostly objective and should offer explanations of any problems encountered.

 **3. Regulatory Reports** Written to show an organization’s compliance with federal, state, and/ or local regulations (or with professional standards). Include financial reports and safety reports.

 **4. Lab Reports** Written to communicate and record results of lab studies can make up part of a report for analysis. Mostly informative, but can also be analytical depending on context.

**How to write informative report?**

Informational reports do not have an argumentative slant. Their goal is to give people the facts so that the reader can make a decision, not the writer. The writer should maintain a neutral attitude when presenting the facts, but spare no energy when it comes to researching in depth and writing clearly. Since a thesis statement presents an argument, an informative paper does not really need one, but it does need a clear focus stated in one sentence.

There are 6 main steps to follow while writing an informative report:

**Step 1:** Find out who wants the report and why. Without performing this audience analysis, it is difficult to start writing. When you talk to the reader, ask what motivated the request for the report, what topic should be covered, and the format that it should be in. A lab report will look very different from a book report, for example, but all informational reports need certain basic things.

**Step 2:** Gather data related to the topic. Use authoritative sources like scholarly, peer reviewed articles, scholarly books, web pages associated with governments or universities, scientific studies, or interviews. If you collect the data yourself, explain, near the start of the paper, the methods used to create questionnaires and surveys.

**Step 3:** State the focus of your report in the last sentence of the first paragraph, and use the rest of the introduction to capture the audience’s attention. Cite some key statistics, quote an expert, or tell an anecdote related to the focus. By stating the focus, you give the reader and yourself a guide. The reader knows what to expect, and you know what to include in the report and what to exclude. Exclude anything that does not relate to the focus.

**Step 4:** List to yourself five to ten main points, depending on the length of the report, that are essential and that relate to the focus. Dedicate one paragraph, or even one section of the report, to each point. Develop each point, using quotations, statistics, examples, summaries and your own analysis and reflection.

**Step 5:** Document your sources. If you quote or summarize, use one of the major documentation styles, Modern Language Association, American Psychological Association, or Chicago, to give credit to the source. Save all source information, including titles, names, publishers, page numbers and dates, as they are necessary in most documentation styles. Different editors, teachers or managers prefer different styles, so know which one is required for this particular report.

**Step 6:** Conclude by stressing the main point of the report, stating, in different words than in the introduction, why it is important.

**Writing Lab Reports:**

**What lab reports and scientific papers do?**

* **Persuade others** To accept or reject hypotheses by presenting data and interpretations
* **Detail data, procedures, and outcomes:** for future researchers
* **Become part of the accepted body of scientific knowledge:** when published unless later disproved
* **Provide an archival record:** for reference and document a current situation for future comparison

**Format:**

The typical lab report includes: title, abstract, introduction, materials and methods, results, discussion, references and literature cited

**Title:**

* Reflect the factual content with less than ten words in a straightforward manner
* Use keywords researchers and search engines on the Internet will recognize

**Abstract:**

Summarize in a concise paragraph the purpose of the report,
data presented, and major conclusions in about 100 - 200 words.

**Introduction:**

* Define the subject of the report: "Why was this study performed?"
* Provide background information and relevant studies: "What knowledge already exists about this subject?"
* Outline scientific purpose(s) and/or objective(s): "What are the specific hypotheses and the experimental design for investigation?"

**Materials and methods:**

* List materials used, how were they used, and where and when was the work done (especially important in field studies)
* Describe special pieces of equipment and the general theory of the analyses or assays used
* Provide enough detail for the reader to understand the experiment without overwhelming him/her. When procedures from a lab book or another report are followed exactly, simply cite the work and note that details can be found there.

**Results**

* Concentrate on general trends and differences and not on trivial details.
* Summarize the data from the experiments without discussing their implications
* Organize data into tables, figures, graphs, photographs, etc. Data in a table should not be duplicated in a graph or figure
* Title all figures and tables; include a legend explaining symbols, abbreviations, or special methods
* Number figures and tables separately
and refer to them in the text by their number, i.e.
	1. Figure 1 shows that the activity....
	2. The activity decreases after five minutes (fig. 1)

**Discussion**

* Interpret the data; do not restate the results
* Relate results to existing theory and knowledge
* Explain the logic that allows you to accept or reject your original hypotheses
* Speculate as necessary but identify it as such
* Include suggestions for improving your techniques or design, or clarify areas of doubt for further research

**References & literature cited**

* Cite only references in your paper and not a general bibliography on the topic
* Alphabetize by last name of the author
* Follow the recommended format for citations

**General style**

* Strive for logic and precision and avoid ambiguity, especially with pronouns and sequences
* Keep your writing impersonal; avoid the use of the first person (i.e. I or we)
* Use the past tense and be consistent within the report
note: "data" is plural and "datum" is singular; species is singular and plural
* Italicize all scientific names (genus and species)
* Use the metric system of measurement and abbreviate measurements without periods (i.e. cm kg) spell out all numbers beginning sentences or less than 10 (i.e. "two explanations of six factors").
* Write numbers as numerals when greater than ten (i.e. 156) or associated with measurements (i.e. 6 mm or 2 g)
* Have a neutral person review and critique your report before submission

**Research Reports**

## There are various parts of research reports so while writing a research report we need to know about these parts.

## Parts of a report:

An objective of organizing a research paper is to allow people to read your work selectively. When I research a topic, I may be interested in just the methods, a specific result, the interpretation, or perhaps I just want to see a summary of the paper to determine if it is relevant to my study.

For most studies, a proper research report includes the following sections, submitted in the order listed, each section to start on a new page. Some journals request a summary to be placed at the end of the discussion. Some techniques articles include an appendix with equations, formulas, calculations, etc. Some journals deviate from the format, such as by combining results and discussion, or combining everything but the title, abstract, and literature as is done in the journal Science. Your reports will adhere to the standard format.

* [Title](http://dwb4.unl.edu/Chem/CHEM869K/CHEM869KLinks/www.ruf.rice.edu/~bioslabs/tools/report/reportform.html#title) Page
* [Abstract](http://dwb4.unl.edu/Chem/CHEM869K/CHEM869KLinks/www.ruf.rice.edu/~bioslabs/tools/report/reportform.html#abstract)
* [Introduction](http://dwb4.unl.edu/Chem/CHEM869K/CHEM869KLinks/www.ruf.rice.edu/~bioslabs/tools/report/reportform.html#intro)
* [Materials and Methods](http://dwb4.unl.edu/Chem/CHEM869K/CHEM869KLinks/www.ruf.rice.edu/~bioslabs/tools/report/reportform.html#methods)
* [Results](http://dwb4.unl.edu/Chem/CHEM869K/CHEM869KLinks/www.ruf.rice.edu/~bioslabs/tools/report/reportform.html#results)
* [Discussion](http://dwb4.unl.edu/Chem/CHEM869K/CHEM869KLinks/www.ruf.rice.edu/~bioslabs/tools/report/reportform.html#discussion)
* [Literature Cited](http://dwb4.unl.edu/Chem/CHEM869K/CHEM869KLinks/www.ruf.rice.edu/~bioslabs/tools/report/reportform.html#literature)
* [Examples](http://dwb4.unl.edu/Chem/CHEM869K/CHEM869KLinks/www.ruf.rice.edu/~bioslabs/tools/report/reportform.html#examples)

[Common errors in student research reports](http://dwb4.unl.edu/Chem/CHEM869K/CHEM869KLinks/www.ruf.rice.edu/~bioslabs/tools/report/reporterror.html) have been collected and summarized, to help you avoid a number of pitfalls. You may also want to keep in mind [how lab reports are usually graded](http://dwb4.unl.edu/Chem/CHEM869K/CHEM869KLinks/www.ruf.rice.edu/~bioslabs/tools/report/reportgrade.html) as you prepare your work.

### Style

In all sections of your paper, use paragraphs to separate each important point (except for the abstract), and present your points in logical order. Use present tense to report background that is already established. For example, 'the grass is green.' Always use past tense to describe results of a specific experiment, especially your own. For example, 'When weed killer was applied, the grass was brown.' Remember - present tense for background, and past tense for results.

### Title Page

Select an informative title, such as "Role of temperature in determination of the rate of development of Xenopus larvae." A title such as "Biology lab #1" is not informative. Include the name(s) and address(es) of all authors, and date submitted.

### Abstract

Summarize the study, focusing on the results and major conclusions, including relevant quantitative data. It must be a single paragraph, and concise. It should stand on its own, therefore do not refer to any other part of the report, such as a figure or table. Avoid long sections of introductory or explanatory material. As a summary of work done, it is written in past tense.

### Introduction

Introduce the rationale behind the study, including

* The overall question and its relevance to science
* Suitability of the experimental model to the overall question
* Experimental design and specific hypothesis or objective
* Significance of the anticipated results to the overall question

Include appropriate background information (but please do not write everything you know about the subject).

###

### Methods and Materials

The purpose of this section is to document all of your procedures so that another scientist could reproduce all or part of your work. It is not designed to be a set of instructions. As awkward as it may seem, it is standard practice to report methods and materials in past tense, third person passive. Your laboratory notebook should contain all of the details of **everything** you do in lab, plus any additional information needed in order to complete this section.

While it is tempting to report methods in chronological order in a narrative form, it is usually more effective to present them under headings devoted to specific procedures or groups of procedures. Some examples of separate headings are "sources of materials," "assay procedures,"cell fractionation protocol," and "statistical methods." Try to be succinct without sacrificing essential information. Omit any background information or comments. If you must explain why a particular procedure was chosen, do so in the discussion.

Omit information that is irrelevant to a third party. For example, no third party cares what color ice bucket you used, or which individual logged in the data. You need not report sources of basic chemicals that would be found in any supply cabinet, such as sodium chloride or potassium phosphate. Report how procedures were done, not how they were specifically performed on a particular day. For example, report "samples were diluted to a final concentration of 2 mg/ml protein;" don't report that '135 microliters of sample one was diluted with 330 microliters of buffer to make the proteins concentration 2 mg/ml."

### Results

Raw data are never included in a research paper. Analyze your data, then present the analyzed (converted) data in the form of a figure (graph), table, or in narrative form. Present the same data only once, in the most effective manner. By presenting converted data, you make your point succinctly and clearly.

Figures are preferable to tables, and tables are preferable to straight text. However, many times a figure is inappropriate, or the data come across more clearly if described in narrative form.

To give your results continuity, describe the relationship of each section of converted data to the overall study. For example, rather than just putting a table in the paper and going on to the discussion, write, 'In order to test the null hypothesis that dust particles are responsible for the blue color of the sky, we observed the results of filtering air through materials of decreasing pore size. Table 1 lists the spectrum of transmitted light at right angles to the light path through air filtered through different pore sizes.' Then present your table, complete with title and headings.

**All** converted data go into the body of the report, after the methods and before the discussion. Do not stick graphs or other data onto the back of the report just because you printed or prepared them separately.

Do not draw conclusions in the results section. Reserve data interpretation for the discussions.

### Discussion

Interpret your data in the discussion. Decide if each hypothesis is supported, rejected, or if you cannot make a decision with confidence. Do not simply dismiss a study or part of a study as "inconclusive." Make what conclusions you can, then suggest how the experiment must be modified in order to properly test the hypothesis(es).

Explain all of your observations as much as possible, focusing on mechanisms. When you refer to information, distinguish data generated by your own studies from published information or from information obtained from other students. Refer to work done by specific individuals (including yourself) in past tense. Refer to generally accepted facts and principles in present tense. For example, "Doofus, in a 1989 survey, found that anemia in basset hounds was correlated with advanced age. Anemia is a condition in which there is insufficient hemoglobin in the blood."

Decide if the experimental design adequately addressed the hypothesis, and whether or not it was properly controlled. One experiment will not answer an overall question, so keeping the big picture in mind, where do you go next? The best studies open up new avenues of research. What questions remain? Did the study lead you to any new questions? Try to think up a new hypothesis and briefly suggest new experiments to further address the main question. Be creative, and don't be afraid to speculate.

### Literature Cited

List all literature cited in your report, in alphabetical order, by first author. In a proper research paper, only primary literature is used (original research articles authored by the original investigators). Some of your reports may not require references, and if that is the case simply state "no references were consulted.

**Examples:**

Give appropriate examples for your research papers. Illustrate the examples.