

HOW TO ORGANIZE A SCIENTIFIC PAPER

Adapted From: <http://www.columbia.edu/cu/biology/ug/research/paper.html>

Scientific research articles provide a method for scientists to communicate with other scientists about the results of their research. A standard format is used for these articles, in which the author presents the research in an orderly, logical manner. This doesn't necessarily reflect the order in which you did or thought about the work. This format is:

TITLE

1. Make your title specific enough to describe the contents of the paper, but not so technical that only specialists will understand. The title should be appropriate for the intended audience.
2. The title usually describes the subject matter of the article: "Effect of Smoking on Academic Performance"
3. Sometimes a title that summarizes the results is more effective: "Students Who Smoke Get Lower Grades"

AUTHORS

1. The person who did the work and wrote the paper is generally listed as the first author of a research paper.
2. For published articles, other people who made substantial contributions to the work are also listed as authors. Ask your mentor's permission before including his/her name as co-author.

ABSTRACT

1. An abstract, or summary, is published together with a research article, giving the reader a "preview" of what's to come. Such abstracts may also be published separately in bibliographical sources, such as Biological Abstracts. They allow other scientists to quickly scan the large scientific literature, and decide which articles they want to read in depth. The abstract should be a little less technical than the article itself; you don't want to dissuade your potential audience from reading your paper.
2. Your abstract should be one paragraph, of 100-250 words, which summarizes the purpose, methods, results and conclusions of the paper.
3. It is not easy to include all this information in just a few words. Start by writing a summary that includes whatever you think is important, and then gradually prune it down to size by removing unnecessary words, while still retaining the necessary concepts.
4. Don't use abbreviations or citations in the abstract. It should be able to stand alone without any footnotes.

INTRODUCTION

What question did you ask in your experiment? Why is it interesting? The introduction summarizes the relevant literature so that the reader will understand why you were interested in the question you asked. One to four paragraphs should be enough. End with a sentence explaining the specific question you asked in this experiment.

MATERIALS AND METHODS

1. How did you answer this question? There should be enough information here to allow another scientist to repeat your experiment. Look at other papers that have been published in your field to get some idea of what is included in this section.
2. If you had a complicated protocol, it may be helpful to include a diagram, table or flowchart to explain the methods you used.
3. Do not put results in this section. You may, however, include preliminary results that were used to design the main experiment that you are reporting on. ("In a preliminary study, I observed the owls for one week, and found that 73 % of their locomotor activity occurred during the night, and so I conducted all subsequent experiments between 11 pm and 6 am.")
4. Mention relevant ethical considerations. If you used human subjects, did they consent to participate? If you used animals, what measures did you take to minimize pain?

RESULTS

1. This is where you present the results you've gotten. Use graphs and tables if appropriate, but also summarize your main findings in the text. Do NOT discuss the results or speculate as to why something happened; that goes in the Discussion.
2. You don't necessarily have to include all the data you've gotten during the semester. This isn't a diary.
3. Use appropriate methods of showing data. Don't try to manipulate the data to make it look like you did more than you actually did.

"The drug cured 1/3 of the infected mice, another 1/3 were not affected, and the third mouse got away."

TABLES AND GRAPHS

1. If you present your data in a table or graph, include a title describing what's in the table ("Enzyme activity at various temperatures", not "My results".) For graphs, you should also label the x and y axes.
2. Don't use a table or graph just to be "fancy". If you can summarize the information in one sentence, then a table or graph is not necessary.

DISCUSSION

1. Highlight the most significant results, but don't just repeat what you've written in the Results section. How do these results relate to the original question? Does the data support your hypothesis? Are your results consistent with what other investigators have reported? If your results were unexpected, try to explain why. Is there another way to interpret your results? What further research would be necessary to answer the questions raised by your results? How do your results fit into the big picture?
2. End with a one-sentence summary of your conclusion, emphasizing why it is relevant.

ACKNOWLEDGMENTS

This section is optional. You can thank those who either helped with the experiments, or made other important contributions, such as discussing the protocol, commenting on the manuscript, or buying you pizza.

REFERENCES (LITERATURE CITED)

There are several possible ways to organize this section. Here is one commonly used way:

1. In the text, cite the literature in the appropriate places:
Scarlet (1990) thought that the gene was present only in yeast, but it has since been identified in the platypus (Indigo and Mauve, 1994) and the wombat (Magenta, et al., 1995).
2. In the References section list citations in alphabetical order.
Indigo, A. C., and Mauve, B. E. 1994. Queer place for qwerty: gene isolation from the platypus. *Science* 275: 1213-1214.
Magenta, S. T., Sepia, X., and Turquoise, U. 1995. Wombat genetics. In: *Widiculous Wombats*, R. Johnson, editor. New York: Columbia University Press. pp 123-145.
Scarlet, S.L. 1990. Isolation of qwerty gene from *S. cerevisiae*. *Journal of Unusual Results* 36: 26-31

OTHER IMPORTANT CONSIDERATIONS:

1. **Write accurately:** Pay close attention to details, such as scientific terminology and units.
2. **Write clearly:** Be careful with spelling and grammar.
3. **Write succinctly:** Don't use more words where fewer words will do. Where you have a choice, use shorter words (e.g., use vs. utilize). Use concise terms instead of phrases (e.g., due to the fact vs. because). Write in the active rather than the passive voice. Use short sentences instead of long one.
4. **Have someone else read your work.**
5. **Use a spellchecker.** However, spellcheckers are not foolproof. See "Candidate for a Pullet Surprise" by Jerrold Zar: <https://www.thoughtco.com/spell-checker-poem-by-mark-eckman-1692348>

EDIT YOUR PAPER!!!

"In my writing, I average about ten pages a day. Unfortunately, they're all the same page."
Michael Alley, *The Craft of Scientific Writing*

A major part of any writing assignment consists of re-writing.

WRITE ACCURATELY

1. Scientific writing must be accurate. Although writing instructors may tell you not to use the same word twice in a sentence, it's okay for scientific writing, which must be accurate. (A student who tried not to repeat the word "hamster" produced this confusing sentence: "When I put the hamster in a cage with the other animals, the little mammals began to play.")
2. Make sure you say what you mean.
Instead of: The rats were injected with the drug. (sounds like a syringe was filled with drug and ground-up rats and both were injected together)
Write: I injected the drug into the rat.
3. Be careful with commonly confused words:
 - Temperature has an *effect* on the reaction.
Temperature *affects* the reaction.
 - I used solutions in various concentrations. (The solutions were 5 mg/ml, 10 mg/ml, and 15 mg/ml)
I used solutions in varying concentrations. (The concentrations I used changed; sometimes they were 5 mg/ml, other times they were 15 mg/ml.)
 - Less food (can't count numbers of food)
Fewer animals (can count numbers of animals)
 - A large amount of food (can't count them)
A large number of animals (can count them)
 - The erythrocytes, which are in the blood, contain hemoglobin.
The erythrocytes that are in the blood contain hemoglobin. (Wrong. This sentence implies that there are erythrocytes elsewhere that don't contain hemoglobin.)

WRITE CLEARLY

1. Write at a level that's appropriate for your audience.
"Like a pigeon, something to admire as long as it isn't over your head." Anonymous
2. Use the active voice. It's clearer and more concise than the passive voice.
Instead of: An increased appetite was manifested by the rats and an increase in body weight was measured.
Write: The rats ate more and gained weight.
3. Use the first person.
Instead of: It is thought
Write: I think
Instead of: The samples were analyzed
Write: I analyzed the samples
4. Avoid dangling participles.
"After incubating at 30 degrees C, we examined the petri plates." (You must've been warm in there.)

WRITE SUCCINCTLY

1. Use verbs instead of abstract nouns
Instead of: take into consideration
Write: consider
2. Use strong verbs instead of "to be"
Instead of: The enzyme was found to be the active agent in catalyzing...
Write: The enzyme catalyzed...

3. Use short words.

Instead of:

possess
sufficient
utilize
demonstrate
assistance
terminate

Write:

have
enough
use
show
help
end

4. Use concise terms.

Instead of:

prior to
due to the fact that
in a considerable number of cases
the vast majority of
during the time that
in close proximity to
it has long been known that

Write:

before
because
often
most
when
near
I'm too lazy to look up the reference

5. Use short sentences. A sentence made of more than 40 words should probably be rewritten as two sentences.

"The conjunction 'and' commonly serves to indicate that the writer's mind still functions even when no signs of the phenomenon are noticeable." Rudolf Virchow, 1928

CHECK YOUR GRAMMAR, SPELLING AND PUNCTUATION

1. Use a spellchecker, but be aware that they don't catch all mistakes.

"When we consider the animal as a hole..." Student's paper

2. Your spellchecker may not recognize scientific terms. For the correct spelling, try [Vision Learning](#) or one of the technical dictionaries on the reference shelf in the university library nearest to you. There are also [science dictionary apps](#) available for your phone.

3. Don't, use, unnecessary, commas.

4. **Proofread** carefully to see if you any words out.

USEFUL BOOKS

Victoria E. McMillan, Writing Papers in the Biological Sciences, Bedford Books, Boston, 1997

The best. On sale for about \$18 at Labyrinth Books, 112th Street. On reserve in Biology Library

Jan A. Pechenik, A Short Guide to Writing About Biology, Boston: Little, Brown, 1987

Harrison W. Ambrose, III & Katharine Peckham Ambrose, A Handbook of Biological Investigation, 4th edition, Hunter Textbooks Inc, Winston-Salem, 1987

Particularly useful if you need to use statistics to analyze your data. Copy on Reference shelf in Biology Library.

Robert S. Day, How to Write and Publish a Scientific Paper, 4th edition, Oryx Press, Phoenix, 1994.

Earlier editions also good. A bit more advanced, intended for those writing papers for publication. Fun to read. Several copies available in Columbia libraries.

William Strunk, Jr. and E. B. White, The Elements of Style, 3rd ed. Macmillan, New York, 1987.

[Strunk's first edition](#) is available on-line.