

## Writing a Research Paper in the Natural Sciences

As students in the natural sciences, we've been writing research papers and lab reports for years. Now, as graduate students, many of the research papers we're working on are headed towards publication—a daunting task. I think we're all aware that publishing our research is necessary to advance to the next stage of our careers. In the academic and scientific communities, publications are the main way that scientists publicize their work, and it is ultimately our papers on which we are judged as scientists.

**What makes a good research paper?** Excellent research of course! However, innovative ideas and cutting edge research are not the only ingredients that make up a good research paper. A great paper is one where the story is presented in a clear and logical way. If the thinking behind the research is clear, the writing will be clear.

### When should you start writing?

You should start writing when you have enough data to tell a story that is complete and makes sense. If you start writing your paper too soon, you may be wasting your time and have to go back and perform additional experiments. If you start writing too late, you run the risk of getting scooped. The key is to think about your paper while you are conducting your experiments.

**Think in Figures.** A helpful method to know if you are ready to write your paper is to lay out your figures in an order in which you think they make sense. Now ask yourself if a reader can come to the main conclusions based on the information laid out in the graphs and figures. Are there any alternative explanations? Is any logical piece missing? Enlist lab members or advisors in reviewing your figures, or give a presentation using your figures to decide if you can tell a complete story.

### First things first: Pre-writing

You will save yourself a lot of time and stress later by spending some time organizing your thoughts and strategically thinking about the logic of your paper before you begin to write.

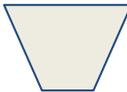
- Review the literature in your field:
  - What has been done? What is known? How does your work fit in?
  - Organize your references (use a reference manager e.g. End Note)
- Who is your audience?
  - Experts in your field or general? What is their prior knowledge?
- Clearly state research questions/objectives/hypotheses.
  - Why did you conduct this research?
- Create an outline!
  - Organize the structure of each section of your paper.
  - Use as a reference when writing your draft.

## Structure of a Research Paper

The structure of a research paper is relatively formulaic. Each section of a research paper contains key pieces of information that a reader will be looking for, and you should be sure to follow this structure in your own writing.

You can think of the organization of certain sections as shapes. For example, the Introduction section is shaped as a funnel because you start with broad background information and then narrow down to the specific question of the paper. More information will be given on each of these sections later.

The table below shows each section that should be included in your research paper, along with its structural shape, and the overall purpose of that section in your research paper.

Paper Component	Shape	Purpose
<b>TITLE</b>		To attract readers and succinctly state the main topic of the paper.
<b>ABSTRACT</b>		To provide a concise summary and establish significance of the paper.
<b>INTRODUCTION</b>		To interest your audience into reading the paper and to provide sufficient context or background information to understand your study.
<b>METHODS</b>		To describe the experimental approach used to arrive at your conclusions.
<b>RESULTS</b>		To describe the major scientific contribution(s) of your study.
<b>DISCUSSION/CONCLUSIONS</b>		To interpret your key findings and draw conclusions based on these findings.

# Guidelines and Checklists for each section of a Research Paper

## TITLE

### **Guidelines:**

- a. Aim to attract readers.
- b. State the main topic of your study.
- c. Make your title strong: It should be clear and complete but succinct.
- d. Your title should separate your article from other articles in your field.

### **Checklist:**

- Does the title attract readers?
- Does the title state the main topic of your study?
- Is the title complete/succinct?

## ABSTRACT



### **Guidelines:**

- a. Include the important parts.
- b. Think of the abstract as a mini-version of the paper.
- c. Do not give equal weight to all parts.
- d. Check journal for word count (generally between 100 and 250 words).
- e. Write this last, extracting information from the body of your paper
- f. Follow below structure as guide:

### **Checklist:**

- Is the question/purpose stated?
- Is the significance of your study clear?
- Have you stated your main conclusions?
- Is all the information in the Abstract consistent with the info in the body of the paper?

Abstract component:	Taken from:	Approx. length:
Background	Introduction	1-2 sentences
Question/purpose	Introduction	1 sentence
Experimental approach	Methods	1 sentence
Results	Results	A few sentences
Conclusion	Discussion/Conclusions	1-2 sentences
Implication(s)	Discussion/Conclusions	1 sentence

## INTRODUCTION



### **Guidelines:**

- a. Follow the funnel structure: begin with background information and narrow down to your specific research objective or question.
- b. Interest your audience and provide context.
- c. Provide pertinent background information, but exclude literature outside the scope of your research.
- d. State the unknown/problem/research gap clearly.
- e. State your question or objectives clearly.

### **Checklist:**

- Have you reviewed the relevant literature and included appropriate references?
  - Is the significance of your study clearly articulated?
  - Have you identified the research gap that your study will help to fill?
  - Have you stated the specific purpose of the paper clearly at the end of the introduction?
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## METHODS



### **Guidelines:**

- a. Provide enough details/references that would allow a trained scientist to replicate your work.
- b. Do not include unnecessary detail.
- c. Explain the purpose for any procedure whose function is not clear.
- d. Be precise (e.g., quantities, time).
- e. If appropriate, use subheadings to organize different materials, variables, and procedures.

### **Checklist:**

- Have you described all the methods you used in your study?
  - Did you provide sufficient details and/or references?
  - Could a trained scientist replicate your work following the methods you described in this section?
  - Were you precise in describing units?
  - Are methods logically grouped and organized?
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## RESULTS



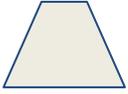
### **Guidelines:**

- a. Report your main findings as well as other important findings.
- b. Organize this section chronologically or from most to least important.
- c. Point the reader to data shown in figures and tables.
- d. Stick to the facts: do not provide conclusions, speculations, or comparisons with other studies.

### **Checklist:**

- Did you present your main findings and other important findings?
  - Did you choose the best method to present information (e.g. tables, figures)?
  - Is the Results section logically organized?
  - Did you include statistical information?
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## DISCUSSION/CONCLUSIONS



### **Guidelines:**

- a. Organize this section in a pyramid structure: start with specifics and then move to the general.
- b. Begin with an interpretation of the key finding(s), which present an answer to the question posed in the Introduction.
- c. Compare/contrast your findings to previous studies.
- d. Describe any limitations of your study.
- e. Mention unexpected findings.
- f. At the end, provide closure: restate your interpretation of the findings and explain the significance/implications of your work.

### **Checklist:**

- Is the Discussion structured as a pyramid?
- Is the answer to the question posed in the Introduction clear in the beginning of the Discussion?
- Have you explained the meaning and significance of your results?
- Have you put your results in context with previous research in this field?
- Have you convinced readers that you have a unique contribution?

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## **Writer's block? Stuck? Don't know where to begin?**

- Organize your materials—your notebook, figures and tables, and references.
- Review articles in your target journal to learn about structure, style, etc.
- Read the author instructions for your target journal.
- Start with a single section or paragraph.
- Write what you want to write, not what you think you should.
- Set deadlines for yourself or have someone else set them for you.
- Know you're not alone—most people experience writer's block or difficulty writing at one time or another.
- Ask co-authors for comments on your draft if you're stuck.

### Refs:

Hofmann, A. *Scientific Writing and Communication*

Swales, J. & Feak, C. *Academic Writing for Graduate Students*

Nancekivell, S. *Writing a Publishable Journal Article: A Perspective from the other side of the desk.*