

## Writing a Scientific Paper

### What is a Scientific Paper?

- ✓ A scientific paper is a written and published report describing original research results.
- ✓ It is an addition to human knowledge; this is a reversible statement (addition of knowledge takes place through scientific papers)
- ✓ A scientific paper is not:
  - a technical report or term paper
    - a paper is worth writing only if it has general implications for knowledge
  - a gospel
    - paper should be scholarly but you're not writing for the ages – others will come after you with newer data and better models.

### The Structure, Format, Content, and Style of a Journal-Style Scientific Paper

#### Why a Scientific Format?

It is a means of efficiently communicating scientific findings to the broad community of scientists in a uniform manner.

This format allows the paper to be read at different levels.

#### The Sections of the Paper:

- Title,
- Authors and Affiliation,
- Abstract,
- Introduction,
- Methods,
- Results,
- Discussion,
- Acknowledgments, and
- References,

The sections appear in a journal style paper in the following prescribed order:

Experimental process	Section of Paper
What did I/We do in a nutshell?	<u>Abstract</u>
What is the problem?	<u>Introduction</u>
How did I/We solve the problem?	<u>Materials and Methods</u>
What did I/We find out?	<u>Results</u>
What does it mean?	<u>Discussion</u>
Who helped me/us out?	<u>Acknowledgments</u> (optional)
Whose work did I/We refer to?	<u>References</u>
Extra Information	<u>Appendices</u> (optional)

### Section Headings:

#### - Main Section Headings:

Each main section of the paper begins with a heading which should be *capitalized*, *centered* at the beginning of the section, and *double spaced* from the lines above and below. Do not underline the section heading OR put a colon at the end.

Example of a main section heading:

## INTRODUCTION

#### - Subheadings:

When your paper reports on more than one experiment, use subheadings to help organize the presentation. Subheadings should be *capitalized* (first letter in each word), *left justified*, and either *bold italics* OR *underlined*.

Example of a subheading:

*Effect of age on Blood pressure values*

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## INTRODUCTION

### Function:

- It establish the context of the work being reported. This is accomplished by discussing the relevant primary research literature (with citations) and summarizing our current understanding of the problem you are investigating;
- State the purpose of the work in the form of the hypothesis, question, or problem you investigated; and,
- Briefly explain your rationale and approach and, whenever possible, the possible outcomes your study can reveal.

The Introduction must answer the questions

- "What we are studying?"
- Why it an important question?
- What did we know about it before wedid this study?
- How will this study advance our knowledge?"

Style:

Use the active voice as much as possible.

Not to use the first person.

**At all costs, avoid the passive voice.**

## Example

- All patients screened were asked to complete an acceptability questionnaire immediately after screening” (not good)

**Versus**

- “ All patients were completed an acceptability questionnaire immediately after screening” (good)

- “The genes were seen to be expressed....” (not good)

**Versus**

- “The genes were expressed....” (good)

Structure:

- The structure of the Introduction can be thought of as an inverted triangle - the broadest part at the top representing the most general information and focusing down to the specific problem you studied.
- Organize the information to present the more general aspects of the topic early in the Introduction, then narrow toward the more specific topical information that provides context, finally arriving at your statement of purpose and rationale.

## MATERIALS AND METHODS

This section is variously called Methods or Methods and Materials.

Function:

- In this section you explain *clearly* how you carried out your study in the following *general* structure and organization
- The Subjects studied (plant, animal, human, etc.) and when (study period) and where the study was carried out.
- Description of the sample size, *inclusion/exclusion criteria, study variables, outcome variables, and its measurement.*

- The experimental OR sampling design (i.e., how the experiment or study was structured. For example, controls, treatments, the variable (s) measured, how many samples were collected, replication, etc.);
- The method for collecting data, i.e., how the experimental procedures were carried out, and,
- How the data were analyzed (qualitative analyses and/or statistical procedures used).

### The information should include:

- How the data were summarized (Means, percent, etc) and how you are reporting measures of variability (SD,SEM, etc)
  - this lets you avoid having to repeatedly indicate you are using mean  $\pm$  SD.
- data transformation, if any.
- statistical tests used with reference to the particular questions they address, e.g.,
  - "A Paired t-test was used to compare mean weight before and after intervention"
  - "*One way ANOVA was used to compare mean weight gain in three different groups*"
- any other numerical or graphical techniques used to analyze the data

### Style:

- The style in this section should read as if you were verbally describing the conduct of the experiment.
  - You may use the active voice to a certain extent, although this section requires more use of third person, passive constructions than others.
  - Avoid use of the first person in this section. Remember to use the past tense throughout - the work being reported is done, and was performed in the past, not the future.
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## RESULTS

### Function:

- The function of the Results section is to objectively present your key results, *without* interpretation, in an orderly and logical sequence using both illustrative materials (Tables and Figures) and text.
- Summaries of the statistical analyses may appear either in the text (usually parenthetically) or in the relevant Tables or Figures (in the legend or as footnotes to the Table or Figure).
- The Results section should be organized around a series of Tables and/or Figures sequenced to present your key findings in a logical order.
- The text of the Results section follows this sequence and highlights the answers to the questions/hypotheses you investigated.
  
- Important negative results should be reported, too.
  
- Authors usually write the text of the results section based upon the sequence of Tables and Figures.

### Style:

- Write the text of the Results section concisely and objectively.
- Use the past tense.
- Avoid repetitive paragraph structures.
- Do not interpret the data here.

### Things to consider as you write your Results section:

- What are the "results"?
  
- Organize the results section based on the sequence of Table and Figures you'll include

### Simple rules to follow related to Tables and Figures:

- ✓ Tables and Figures are assigned numbers separately and in the sequence that you will refer to them from the text.
  - The first Table you refer to is Table 1, the next Table 2 and so forth.
  - Similarly, the first Figure is Figure 1, the next Figure 2, etc
  
- ✓ *Each* Table or Figure must include a brief description of the results being presented and other necessary information in a legend.
  - Table legends go above the Table; tables are read from top to bottom.

- Figure legends go below the figure; figures are usually viewed from bottom to top.
- ✓ When referring to a Figure *from the text*, "Figure" is abbreviated as Fig., e.g., Fig. 1. Table is never abbreviated, e.g., Table 1.
- ✓ The body of the Results section is a text-based presentation of the key findings which includes references to each of the Tables and Figures.

### Some things to avoid:

- ☒ Do not reiterate each value from a Figure or Table - only the key result or trends that each conveys.
- ☒ Do not present the same data in both a Table and Figure. Decide which format best shows the result and go with it.
- ☒ Do not report raw data values when they can be summarized as means, percents, etc.

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- Statistical test summaries (test name, *p*-value) are usually reported parenthetically in conjunction with the biological results they support.
  - Always report your results with parenthetical reference to the statistical conclusion that supports your finding.
  - This parenthetical reference should include the statistical test used and the level of significance (test statistic and DF are optional).
  - For example, if you found that the mean height of male subjects was significantly larger than that of female subjects, you might report this result and your statistical conclusion as follows:
    - "Males (180.5 ± 5.1 cm; n=34) averaged 12.5 cm taller than females (168 ± 7.6 cm; n=34) in the AY 1995 pool of subjects (two-sample t-test,  $t = 5.78$ , 33 d.f.,  $p < 0.001$ )."
  - Present the results of your experiment (s) in a sequence that will logically support (or provide evidence against) the hypothesis, or answer the question, stated in the Introduction.
  - Report *negative* results - they are important!

Always enter the appropriate **units** when reporting data or summary statistics.

- for an *individual value* you would write, "the mean length was 10 m", or, "the maximum time was 140 min."
  - When including a measure of variability, place the unit *after* the error value, e.g., "...was 10 ± 2.3 m".
  - Likewise place the unit after the last in a *series of numbers* all having the same unit. For example: "lengths of 5, 10, 15, and 20 m", or "no differences were observed after 2, 4, 6, or 8 min. of incubation".
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## Discussion

### Function:

- The function of the Discussion is to interpret your results in light of what was already known about the subject of the investigation, and to explain our new understanding of the problem after taking your results into consideration.
- The Discussion will always connect to the Introduction by way of the question (s) or hypotheses you posed and the literature you cited, but it does not simply repeat or rearrange the Introduction.
- Instead, it tells how your study has moved us forward from the place you left us at the end of the Introduction.

### Fundamental questions to answer here include:

- Do your results provide answers to your testable hypotheses? If so, how do you interpret your findings?
- Do your findings agree with what others have shown? If not, do they suggest an alternative explanation or perhaps a unforeseen design flaw in your experiment (or theirs?)
- Given your conclusions, what is our new understanding of the problem you investigated and outlined in the Introduction?
- If warranted, what would be the next step in your study, e.g., what experiments would you do next?

### Style:

Use the active voice whenever possible in this section.

Watch out for wordy phrases; be concise and make your points clearly.

### Approach:

- ✓ Organize the Discussion to address each of the experiments or studies for which you presented results; discuss each in the same sequence as presented in the Results, providing your interpretation of what they mean in the larger context of the problem.
  - ✓ Do not waste entire sentences restating your results; if you need to remind the reader of the result to be discussed, use "bridge sentences" that relate the result to the interpretation:
  - ✓ "The slow response of the lead-exposed neurons relative to controls suggests that...[interpretation]".
  
  - ✓ You must relate your work to the findings of other studies - including previous studies you may have done and those of other investigators.
  
  - ✓ Do not introduce new results in the Discussion.
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### **Acknowledgments (included as needed)**

- If, in your experiment, you received any significant help in thinking up, designing, or carrying out the work, or received materials from someone who did you a favor by supplying them, you must acknowledge their assistance and the service or material provided.
  
  - Place the Acknowledgments between the Discussion and the References.
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### **ABSTRACT**

#### Function:

An abstract summarizes the major aspects of the entire paper in the following prescribed sequence:

- the *question (s) you investigated* (or purpose), (from Introduction)
  - state the purpose very clearly in the first or second sentence.
  
- the *experimental design and methods* used, (from Methods)
  - clearly express the basic design of the study.
  - Name or briefly describe the basic methodology used without going into excessive detail-be sure to indicate the key techniques used.

- the *major findings* including *key quantitative results*, or *trends* (from Results)
  - report those results which answer the questions you were asking
  - identify trends, relative change or differences, etc.
- a brief summary of your *interpretations* and *conclusions*. (from Discussion)
- clearly state the implications of the answers your results gave you.

The Abstract helps readers to decide whether they want to read the rest of the paper, or it may be the only part they can obtain via electronic literature searches or in published abstracts.

### Style:

- The Abstract is ONLY text.
- Use the active voice.
- Write your Abstract using concise, but complete sentences, and get to the point quickly.
- Use past tense.
- Maximum length should be 200-300 words, usually in a single paragraph.

### The Abstract SHOULD NOT contain:

- ☒ lengthy background information,
- ☒ references to other literature,
- ☒ elliptical (i.e., ending with ...) or incomplete sentences,
- ☒ abbreviations or terms that may be confusing to readers,
- ☒ any sort of illustration, figure, or table, or references to them.

### Strategy:

- Although it is the first section of your paper, the Abstract must be written last since it will summarize the paper.
- To begin composing your Abstract, take whole sentences or key phrases from each section and put them in a sequence which summarizes the paper.
- Then set about revising or adding words to make it all cohesive and clear.
- As you become more proficient you will most likely compose the Abstract from scratch.

### Check your work:

- Once you have the completed abstract, check to make sure that the information in the abstract completely agrees with what is written in the paper.
  - Confirm that all the information appearing the abstract actually appears in the body of the paper.
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## References

### Function:

- The References section gives a numerical listing of the references that you actually cited in the body of your paper.

### Citing References in the Body of the Paper

- Throughout the body of your paper (primarily the Introduction and Discussion), whenever you refer to outside sources of information, you must cite the sources from which you drew information.
- The simplest way to do this is to give number (s) chronologically in superscript at the end of sentence of the text., e.g., It has been found that cancer cases who are exposed to estrogens has lower survival time than the controls.<sup>1,2</sup>
- When citing information from another's publication, be sure to report the *relevant* aspects of the work clearly IN YOUR OWN WORDS.
- Provide a reference to the work as soon as possible after giving the information.

### DO NOT DO THE FOLLOWING:

- DO NOT USE FOOTNOTES
- DO NOT USE DIRECT QUOTES From Published Material. Take the information and *put it into your own words.*

### List of References in the Reference Section

- List the references chronologically as appear in the text.
- Each reference includes: reference number, author's name, article title, journal title, year of publication, volume number, issue number and page number.

### Formats for Complete Citations Used in the Reference Section

- You must provide complete citations for each of the published articles cited in your paper.
- The format for entries in the Reference section differs for books and for journal papers because different kinds of information must be provided.

## Specific Format Models

### **Journal Article: Single author**

1. Bugjuice B. Physiological effects of estrogen on mouse courtship behavior. J Physiol 1970; 40(2):140-145.

### **Journal: Two authors**

2. Bugjuice B and Timm T. The role of whisker length in mouse nose-twitch .....courtship behavior. J Physiol 1989; 61(3):113-118.

### **Journal: Multiple authors**

3. Bugjuice B, Cratchet R and Timm T. The role of estrogen in mouse .....courtship behavior changes as mice age. J Physiol 1990; 62(6):1130-1142.

4. Bugjuice B, Cratchet R, Timm T et al. Estrogen, schmestrogen!: Mouse xxxx(*Mus musculus*) as a dietary alternative for humans. J Nutrition 1994 ; 33(6):113 -114.

### **Author(s) Unknown or Not Named**

- If the authorship of a paper or other document is not provided, cite the author using the word "Anonymous" in the place of the authors name(s). e.g.

5. Anonymous. STD's and You: A Survival Guide for College Students in the 20th Century. 1979; Publ.#12-1979, Waazah County Health Department, Popville, Maine. 6 p.

### **Book: single author**

6. Gumwad G. Behavior patterns of mice. 2nd ed, 1952. New York: Harper & Row. Pp 347.

### **Book: multiple authors**

7. Huth J, Brogan MT, Dancik B et al. Scientific format and style: The CBE manual for authors, editors, and publishers. 6th ed, 1994. Cambridge: Cambridge University Press. Pp 825.

### **Book: authors contributing a specific chapter**

8. Kuret J and Murad F. Adenohypophyseal hormones and related substances. In: Gilman A, Rall T Nies A, Taylor P, editors. The pharmacological basis of ....therapeutics. 8th ed, 1990. New York: Pergamon. p. 1334-60.

**Thesis: Theses and dissertations should be cited as follows:**

9. Mortimer R. A study of hormonal regulation of body temperature and consequences for reproductive success in the common house mouse (*Mus musculus*) in Nome, Alaska. Masters Thesis 1975, University of Alaska, Anchorage. Pp 83.

**World Wide Web/Internet source citations:**

WWW citation should be done with caution since so much is posted without peer review. When necessary, report the complete URL including the site and author's name: e.g.

10. Gumwad B. Hormonal regulation of body temperature and consequences for reproductive success in the common house mouse.  
<http://www.csu.edu/~gumwad/hormones/onlinepubs.html>).

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## Appendices

### Function:

- An Appendix contains information that is non-essential to understanding of the paper, but may present information that further clarifies a point without burdening the body of the presentation.
- An appendix is an *optional* part of the paper, and is only rarely found in published papers.

### Headings:

- Each Appendix should be identified by a Roman numeral in sequence, e.g., Appendix I, Appendix II, etc.
- Each appendix should contain different material.

Some examples of material that might be put in an appendix (not an exhaustive list):

- raw data
- maps (foldout type especially)
- extra photographs
- explanation of formulas, either already known ones, or especially if you have "invented" some statistical or other mathematical procedures for data analysis.
- specialized computer programs for a particular procedure
- full generic names of chemicals or compounds that you have referred to in somewhat abbreviated fashion or by some common name in the text of your paper.
- diagrams of specialized apparatus.

### Figures and Tables in Appendices:

- Figures and Tables are often found in an appendix. These should be formatted as discussed previously (in Tables and Figures), but are numbered in a separate sequence from those found in the body of the paper.
- So, the first Figure in the appendix would be Figure 1, the first Table would be Table 1, and so forth. In situations when multiple appendices are used, the Table and Figure numbering must indicate the appendix number as well.

## GENERAL STYLE

- Use “Spelling and Grammar” option in Microsoft Word.
- However, remember that Spell check will only highlight words that do not correspond to an entry in the dictionary.  
     Spell check will not find any mistakes of your text !
- **Paragraphs** are important to break the text up into readable units. They should be about half a double-spaced, typewritten page in length.
- Avoid excessive use of **boring verbs** such as “show, observe, occur, exhibit....”
- Avoid **complex** ways of saying a **simple** thing
  - “The results showed protection by the vaccine”  
     versus  
     “The vaccine protected”
  - “The results showed that cases weight increased”  
     versus  
     “The cases weighed more”.
- Use of “suggest that ....” ; “hypothesize that....” “possible that....”  
     These phrases do not need “may”, “might” e.g.

“Our results suggest that Hoxa3 may be involved in thymus development” **(not correct)**

“Our results suggest that Hoxa3 is involved in thymus development” **(correct)**

“It is possible that regular exercise may control blood glucose levels in type-II diabetic patients”.  
**(not correct)**

“It is possible that regular exercise controls blood glucose levels in type-II diabetic patients”.  
**(correct)**

## Clarity

- **Clear**
  - **Exact**
    - **Ambiguity, inconsistency**
  - **Concise**
    - **Least words**
    - **Short words**
    - **One word vs many**
- 

## Simplify

- a majority of = most
  - at the present time = now
  - give rise to = cause
  - in some cases = sometimes
  - is defined as = is
  - it is believed that = I think
  - on the basis of = by
  - pooled together = pooled
  - subsequent to = after
  - with the result that = so that
- 

## Bad Writing

- Words don't do justice to your ideas.
- If multiple mistakes in spelling and syntax, reviewer suspects similar sloppiness in your study.

Thank You