

COMPONENTS OF A RESEARCH ARTICLE

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Title

Purpose: To attract readers interested in this field of study. The importance of the title cannot be overstated as it is a major determinant of whether the paper will be read. It is the *only* aspect of the article that appears in tables of contents and in many of the databases used for literature searches.

Content: The title should indicate the focus of the paper, and should contain enough relevant “keywords” (i.e., search terms) to enable readers to find this paper when searching a relevant database.

Style: There are two types of titles:

1. *Descriptive* titles, which states the focus of the study:

The effect of heat on ice.

2. *Conclusion* titles, which provide the authors’ main conclusion from their study.

Heat melts ice.

For research articles, we prefer a descriptive title. It “lets the data speak for themselves” (an important concept in research) and allows the author to provide the necessary restrictions on the conclusions, restrictions that usually cannot be accommodated in a title. (For example, that heat melts ice only as long as sufficient time is provided to allow the ice molecules to reach the melting point of water, which is 0°C for pure water at sea level.)

There is another reason for preferring descriptive titles: Should evidence later come to light that indicates the authors’ conclusion is incorrect, the authors’ curriculum vitae will not contain a permanent reminder of this mistake! In some cases, a journal’s *Instructions to Authors* will specify which style of title to use.

Often authors are asked to provide a second, briefer title. Referred to as the *running title*, this title will appear as a header on every other page of the printed article. Like the full title, the running title should be chosen with care.

Length: A title should be short yet provide enough keywords so that individuals will be able to find it when searching relevant databases. A general recommendation is 5-10 words.

Authors

Purpose: To specify the individuals responsible for the research presented in the paper.

Content: The definition of who should be an author (and in what order the list should be provided, see below) varies with the field, the culture, and even the research group. Because of this potential for ambiguity, the rules to be used for determining authorship, including the order of authors, should be clearly agreed upon at the outset of a research project.

Our belief is that authorship denotes an “intellectual contribution” to the work, and that an author should be able to explain and defend the work. This definition of authorship is probably the most common one among researchers and journal editors. Note that within this framework, “honorary authorship” — listing someone as an author who has **not** made an intellectual contribution (e.g., the head of the department or that individual who provided the funds) — would be considered unethical.

In many areas of science, students typically publish papers in which their advisor is an author. However, in some other fields, e.g., education and many areas of the humanities, students frequently are the sole author on their papers.

Independent of the method used to determine authorship, it is *essential* that all authors have given their consent to be designated as such and have approved the final version of the manuscript. One author is chosen as the “corresponding author.” The editor of the journal will direct all correspondence to this individual who then has responsibility for keeping the other authors up-to-date with regard to the status of the manuscript.

Style: Like authorship, the *order* in which the authors are listed varies with field and culture. Often the order of the authors denotes their contribution to the work. For example, in some fields the first author has made the largest contribution, the remaining authors are listed in descending order of effort. On the other hand, in many fields the senior author (the one responsible for overseeing the project) is listed last, and the person that did most of the day-to-day work on the project is listed first. A third possibility, no longer very common, is to list the authors alphabetically.

When possible, it is advisable for researchers to pick a format for their name that they will continue to use throughout their professional life. Thus, John A. Jones, John Jones, and J. A. Jones are each sufficiently different that it might be difficult for someone to know that each name refers to the same author. Changing one's name because of marriage provides a particular challenge in this regard. Some individuals choose not to change their professional name under these circumstances.

Addresses

Purpose: To indicate the institution(s) at which the research was performed, and to provide readers with a way of contacting the authors.

Content: There are three types of addresses listed on a paper:

1. The *main addresses* listed under the names of the authors indicate where the work was performed.
2. The *corresponding address* is usually listed as a footnote to the list of authors. This indicates to the publisher and, later, to the readers, where the “corresponding author” can be contacted regarding any questions related to the article. Recently, many authors have been including multiple forms of “addresses,” including regular mailing addresses, fax numbers, and email addresses.
3. *Current addresses* are often listed for any authors who have moved to a different institution between the time that the research was performed and the manuscript is published.

Note that if an author has moved since completing the research, it is inappropriate to list their current address as the main address. One of the criteria for evaluating an institution is the nature of the work that is done under their auspices, and thus an accurate indication of this credit should be provided.

Style: If the research was conducted at more than one department or institution, then superscripts should be used to indicate which author worked in which location.

Abstract

Purpose: To provide a brief summary of the paper. Along with the title, this is one of the most important components of a research article. After reading the title, researchers commonly scan the abstract to determine what the authors found, and based on this information they often decide if they will read the rest of the paper.

Content: The abstract is written as a mini-paper, i.e., it contains the following information in this order:

1. *introduction*: a few sentences to provide background information on the problem investigated
2. *Methods*: techniques used
3. *Results*: the major results presented in the paper; provide quantitative information when possible.
4. *Discussion*: the authors’ interpretation of the results presented
5. *Final summary*: the major conclusions and “big picture” implications. Note that this is the most important part of the abstract, as researchers will often read this part of the abstract first, to see if the implications of the study are important enough to warrant the reading of the full paper.

In most cases, *abbreviations* are not permitted in an abstract.

Searchable databases and on-line journals now make it relatively easy to obtain titles and abstracts of scientific publications. One of the implications of this is that it can no longer be assumed that only specialists in one’s discipline will read the abstract. Indeed, the readership can

now be assumed to include policy makers, and both advocates and opponents of the research performed. Thus, authors are advised to take this into account when writing their abstract by (1) making it as intelligible as possible to a general readership, and (2) taking extra care to avoid stating things that might be misconstrued by readers who are uninformed and/or unsupportive of the type of research described.

Tense: The abstract should be written in the past tense for the authors' work, present tense for general knowledge and other researchers' work.

Length: The number of words permitted in the abstract is usually specified in a journal's *Instructions to Authors*. Commonly it is 150-300 words.

Introduction

Purpose: To provide the reader with background on the research described in the paper.

Content: The introduction consists primarily of the following types of information, generally provided in this order:

1. *Why the study was undertaken:* What gap in the knowledge of the field were the authors trying to fill by undertaking this study? What problem were the authors trying to address?
2. *The nature of the work performed:* The variables that were investigated and the methods that were used.
3. *The state of the problem at the end of the study:* A brief statement of the major findings presented in the paper, and implications of the study — for example, how the work contributes to “the big picture,” questions left unanswered, new questions that have emerged.

Note: whereas the information from #1 and #2 are essential components of an introduction, some individuals believe that the information from #3 is optional. We strongly recommend including this information as it helps the reader to evaluate more accurately what they are reading in the sections that follow. This point helps to highlight one of the major distinctions between scientific writing and many other types of prose writing — *in scientific writing everything is done to avoid mystery or suspense*.

It is essential that the Introduction should provide a brief but scholarly review of the relevant literature with appropriate references (see “References,” below). Authors should neither unduly inflate their contributions nor obscure controversy by ignoring papers that have already been published.

Abbreviations should generally not be used in the title or abstract, and only sparingly in other parts of the manuscript. A rule of thumb is not to use an abbreviation unless the word is used at least 10 times or is best recognized in its abbreviated form. When an abbreviation is to be employed, it should be defined the first time it is used and then always used thereafter. For example,

The questionnaire was given to 100 employees of the Environmental Protection Agency (EPA), as well as 50 former EPA employees.

Most journals will provide a list of abbreviations that do not need to be defined because they are commonly used. Consult the *Instructions for Authors*.

Tense: What the authors did/found is in the past tense; everything else is in the present tense.

Length: Generally not more than 500 words.

Methods

Purpose: The methods section serves two functions: (1) to enable readers to evaluate the work performed (e.g., did the authors use the most appropriate and accurate techniques for their work?), and (2) to permit readers to replicate the study if they desire to do so.

Content: All aspects of the methodology used in the study must be described thoroughly enough so that scientists working in that field would be able to replicate the work. This includes both what was used as well as what was done. Thus, sometimes this section is referred to as “*Methods and Materials*.”

If the method has already been published in the scientific literature (whether or not it was written by the same authors), readers should be referred to the original description for the details of the method. However, it is important to include enough information so that readers are able to evaluate the work being presented without having to refer to another publication. This means specifying the critical variables for that type of work, for example, how long the samples were incubated, how many minutes subjects were allowed to work on a task, or what strain of laboratory rats were used. In addition, it is essential to indicate any deviations from the method cited.

Often the company (including city and state) that manufactures a particular reagent is specified to reduce any ambiguity about what was used; likewise, the model number for a piece of equipment is often indicated.

Tense: Past tense.

Style: If several different procedures are described, it is preferable to subdivide the methods section via the use of headings. This enables readers to refer quickly back to a specific method.

Results

Purpose: To provide the data collected.

Content: The contents of the Results section depend on type of article:

In *full-length research articles*, the more common type of article, only data - what was observed - is included in this section. Interpretations should be reserved for the discussion section. The idea behind this format is to “let the data speak for themselves.” However, some authors like to include some introductory or transition material to help the flow of this section.

In *short research articles* (sometimes called “short” or “brief” communications), results and discussion (interpretation) are sometimes mixed. Refer to the journals’ *Instructions to Authors* for guidance.

Tense: Authors’ results should be in past tense, and general statements in present tense.

Style: If the results of several different experiments are described, it is preferable to subdivide this section via the use of headings.

Length: This usually is the shortest section of a manuscript.

Discussion

Purpose: To provide the reader with a plausible interpretation of the data reported and to relate these findings to what other investigators have found.

Content: The section provides the following information, generally in this order:

1. *Summary of conclusions:* what the authors conclude from their data, for example, relationships between variables, trends, etc.
2. *Relation to other results:* the relation of these findings to previous work, e.g. “supports the findings of Alvarez et al., (1994)” or “is contrast to ...”
3. *Aberrant results:* any abnormalities or exceptions inherent in the data or in relation to with respect to the scientific literature, and if possible, explanations for these aberrations. (Note: item #3 and #4 may be intermixed.)
4. *Implications:* theoretical or practical implications of the work, i.e., “the big picture”
5. *Grand summary:* a summary of the results and conclusions reported in the paper

Tense: Current knowledge is stated in present tense, the author’s work is stated in past tense.

Style: If headings were used in the results section, it is very convenient for the reader if the relevant portion of the discussion is presented under the same headings.

Length: generally, up to 1500 words.

Acknowledgments

Purpose: To recognize and thank those individuals and organizations whose contributions to the work presented should be acknowledged but are not extensive enough to merit authorship.

Content: When applicable, the following information is presented in this order:

1. Individuals other than authors who made a significant contribution to the research by donating important reagents or materials, collecting data, providing extensive advice on drafts of the manuscript, etc. Typically, the nature of the contribution is noted; for example

The authors thank Dr. Marcia Jones for providing the genetically modified mice used in these studies, and Mr. David Wendall for his assistance in analyzing the tissue samples.

2. If the work has been presented at a conference, then this is often noted. For example,

Portions of this work were presented at the 25th Annual Society for Neuroscience Meeting, November 11-16, 1996, San Diego, CA.

3. Organizations that funded the research. The general format for this information is

This work was supported by U.S. Public Health Service Grant MH43947.

Note that it is **essential** to get permission from any individual whose help is acknowledged. Also, many scientific societies and journals are indicating that it is essential to disclose any financial support that has been provided for the work.

Length: Limit to significant contributors.

References

Purpose: To provide the full citation for article referenced in the text.

Content: A complete reference includes all of the authors' names, the title of the article, the journal name, the volume number, page numbers, and the year of publication.

Style: A wide range of styles is used for citing references in the text and bibliography. Check the journal's *Instructions to Authors* for information about the content and formatting of references.

Within the text, articles are cited by providing the author and year of the article (e.g., Fischer and Zigmond, 1996). When there are more than two authors, the first author is provided together with *e. al.* (e.g., Fischer et al., 1996). If more than one reference is cited for a given point, they are usually listed in chronological order (e.g., Zigmond and Fischer, 1995; Fischer et al., 1996). If there is any ambiguity, a letter can be added to the year of publication (e.g., Fischer et al., 1995a; 1995b).

At the end of the paper a list of references, or bibliography, is provided. This list must be limited to the references cited within the text and most often is provided in alphabetical order.

In some cases citations appear in the text as numbers, usually a superscript, which then refer to a particular item in the reference list.

It is the obligation of the authors to provide a scholarly listing of the primary references of relevance to the paper. Authors are obliged to do a thorough review of the key areas of the scientific literature as part this process. In general, original *research* articles rather than *review*

articles should be cited, and the research articles should be the earliest ones that made the particular finding.

It is essential that authors check each reference that they cite. Simply copying a reference from the bibliography of a published paper is inadequate since errors in referencing are very common. In checking a reference, authors must not only make sure that the citation is accurate but also that the text actually supports the point for which it being used as a reference.

References that are not readily available or are in a language not understood by the author present a particular challenge. In the former case, most libraries provide a service that enables authors to obtain papers from a wide range of other libraries. An alternative that is sometimes available is to contact directly the author of the article in question and request a copy.

Articles in foreign languages sometimes provide enough information in their tables and figures to permit an accurate comprehension of their results, even if the language itself is not understood. In this regard it is helpful that a number of scientific terms are the same in English as in many other languages. Alternatively, it usually is possible to have an article translated by a local service.

If a reference cannot be checked by the author, the only alternative to not citing it is to cite it as a secondary reference (e.g., Hooke, 1665, as cited in Fischer, 1995).

If citations are needed for more than one point in a sentence, it is helpful for the reader if the citations appear throughout the sentence, rather than as a collection at the end. For example,

Previous studies have shown that this compound can exist in a solid (Wang and Beauford, 1993), liquid (Jones et al., 1992), or gaseous (Diaz, 1995) state.

Length: Ideally, a paper will list all the references necessary to document each point that is made by the authors. In practical terms, however, most journals will impose a limit in order to conserve space. A rule of thumb is no more than 6 references for a particular point and no more than 100 references per paper.

Tables and Figures

Purpose: To report data that are too numerous or complicated to be described adequately in the text; to reveal trends or patterns in the data.

Content: Tables; possible figures include graphs (bar, line, scatter), diagrams, cartoons (i.e., chemical structures or mechanisms), and photographs.

Style: Figures are usually in black and white. Color is extremely expensive to publish, and should only be used when it provides unique information. (Note: For further details see “Construction of Tables and Figures,” which will be posted soon.)

Number: Limit the number of tables and figures to those that provide essential information that could not adequately be presented in text.

Table and Figure Legends

Purpose: To provide a knowledgeable reader with the information required for understanding the table or figure.

Content: The composition of a legend depends on the item it refers to. It should provide information regarding the conditions of the experiment, but not give a summary or interpretation of the results. In addition, statistical information is often provided. This may include

1. The number of times an experiment was performed or a condition was tested.
2. What the values in the table or figure represent, for example *mean \pm S.E.M.* (standard error of the mean)
3. The statistical test used in analyzing the data
4. Whether the test was “one-tailed” or “two-tailed” (if relevant)
5. The *p* value that was used in determining significance
6. If an asterisk or other mark is used in the table or graph to denote statistically significant results, then this mark should be defined.

For example, the statistics portion of a figure legend might look like this,

*n=5 for each condition. Values represent mean \pm S.E.M. Data were analyzed using a one-tailed Student's t-test. * denotes significance, $p < 0.05$.*

Tense: Past tense.

Style: Each table and figure should be understandable on its own, without reference to the text.

Within a manuscript, the placement of the legend varies depending on whether it refers to a table or figure:

Table: The title, table, and legend should appear on the same page, in the order listed.

Figure: Each figure should appear on a separate page. The numbered legends are listed one after another (i.e., several to a page). The title for a figure comprises the first sentence in the figure legend.

Bibliography of Resources

There are many useful books about writing research articles. We have listed below a selection of the best, those that we believe deserve a place in every technical writer's library.

1. Briscoe, M.H. *Preparing Scientific Illustrations: A Guide to Better Posters, Presentations, and Publications*, 2nd Edition. New York: Springer, 1996.

We cannot overstate the usefulness of this book. If you have questions about constructing tables and figures, the answer is probably in here.

2. Council of Biology Editors. *Scientific Style and Format: The CBE Manual for Authors, Editors, and Publishers*, 6th Edition. NY: Cambridge University Press, 1994.

Excellent reference text.

3. Woodford FP (1999) *How to Teach Scientific Communication*. Reston, VA: Council of Biology Editors

An outstanding guide to how to teach writing. Includes a number of "before and after" examples.

4. Day, R. A. *How to Write and Publish a Scientific Paper*, 5th Edition. Phoenix: Oryx Press, 1998.

There are a great many books on the subject; this is the best — wise and witty, takes you from creating the title to checking the galley proofs. Robert Day has been our teacher and the inspiration for these workshops.

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