How to Write and Publish a Scientific Paper

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A scientific experiment is not complete until results are published; no matter how spectacular are the results. The only way to authenticate new scientific knowledge is by publishing them. No need for a plumber to write about pipes, nor its necessary for a lawyer to write about cases. However, for the research scientist, it is essential to provide a written document showing what was done, how it was done, why it was done, and what was learned out of it. Reproducibility is the keyword, and that what makes scientific writing unique.

The scientist must not only do science, but must write science. Bad writing can prevent or delay the publishing of good science. When educating scientists, it is of least importance to tell them how to write their findings in an acceptable scientific way. The purpose of this paper is to provide you with essential information on how to write and build up a scientific paper.

What is scientific writing?

The key to scientific writing is clarity. Successful scientific experimentation is the result of a clear mind attacking a clearly stated problem and producing clearly stated conclusion. The most important ingredients in a scientific paper are being clear, simple, and well ordered. Another important ingredient is the use of appropriate English language.

Scientific writing as we know it today relies on the IMRAD system (Introduction, Materials and Methods, Results, and Discussion). Simply, the purpose of the
introduction is to state the nature of the problem studied and its necessary background. The Materials and Methods explain how the problem was studied. Findings of the study are explained in the results section and meanings of such findings are explained in the discussion.

What is a scientific paper?

A scientific paper is a written and published report describing original research results. This is a very short general definition. To properly define “scientific paper” one must define the mechanism that creates a scientific paper. Therefore, to appropriately define scientific paper it has to meet the criteria of a scientific paper which includes:

- The 1st publication of original research results.
- In the form where by peers of the author can report the experiment and test the conclusion.
- In a journal or other source document readily available within the scientific community.

How to prepare the title

First impressions are always strong impressions. Authors should always remember that the title might be read by thousands of people. Only few, if any, will be interested in reading the entire paper. Therefore, a short, descriptive, meaningful title should be used. A good title is that with the fewest possible words that adequately describe the content of the paper.

There is always a debate regarding the length of the title. Too short titles will not give an idea about what is coming next. On the other hand, too long titles are often less meaningful and contain many waste words. Titles like “Studies on Brucella” is not very helpful to the potential reader. A reader would ask: what studies? Taxonomic, Biochemical? Genetic? Or medical? As stated above, titles should be clear and describe the content of the paper. If a reader reads a title like “Action of Streptomycin on Mycobacterium tuberculosis” he would ask him/her self: what action? Modifying the title to look like “Inhibition of growth of Mycobacterium tuberculosis by Streptomycin” is more meaningful and descriptive.
Syntax (word order) in a title is very important. Most of the grammatical errors in titles are due to faulty word order or syntax. For example: “Mechanism of suppression of non-transmissible pneumonia in mice induced by Newcastle disease virus”. What was induced? Mice or pneumonia? Another example: “Multiple infections among new-born results implantation with Staphylococcus aureaus” Is it the staph of life? Another nice example is the title “Preliminary canine and clinical evaluation of a new antitumor agent. What a nice canine training. Dogs evaluating drugs. Well’ dogs are not the only smart animals. Bacteria are also smart if you consider this title “Characterization of bacteria causing mastitis by gas liquid chromatography”. Isn’t it amazing that bacteria can use GLC?

The title of a paper is not a sentence. It is a label. Words should be selected accurately to represent the context of the paper. Moreover, it has to be in a format suitable for a machine indexing system. Titles should not contain any abbreviations or jargons. However, there are always acceptable abbreviations that can be used (e.g. DNA). Some authors prefer to use subtitles especially if they are publishing a series of papers. This is not always welcomed. Each published paper should present results of an independent experiment.

How to list the Authors and addresses

The easiest part when writing a scientific paper is to list the authors and addresses. However, in some cases colleagues may become enemies because they could not agree on whose name should be listed or in what order. There are no agreed upon rules on whose name goes first. Some journals used to publish authors name in an alphabetical order. A general tendency used by many authors is to list the most senior author last. In some papers, nowadays, the most senior author is placed first in the list. What everybody would agree on is to list the person who did most of the work first on the list. This rule is acceptable by authors and publishers.

When writing a scientific paper there is sometimes a debate on whose name should be listed as author. A general rule that is being used by many is to include the name of the head of the laboratory or team (usually a senior well known figure) as an author even if he/she didn’t contribute to the work being presented. This usually helps in granting an acceptance for publication in some journals that send the names of authors to peer reviewers. The author is defined as the one who takes intellectual
responsibilities for the research results being reported. Author name should be listed as first name, followed by middle initial, then the last name. Degrees should be listed after names and may appear in footnotes. The easiest way is to consult a recent issue of the journal you intend to send the manuscript to. Addresses serve two purposes. They identify the author and provide the mailing address. If there is more than one author and more than one address an abbreviation is usually given to each address and it appears after the author’s name.

How to prepare the abstract

The abstract is viewed as a mini-version of the paper. It should provide a brief summary of each of the main sections of the paper. A well prepared abstract enables reader to identify the basic content of the paper quickly and accurately and decide its relevance to their interest and whether they need to read the entire paper. In the abstract should (1) State the principle objective and scope of the investigation, (2) Describe the methodology employed, (3) Summarize the results, and (4) State the principle conclusion. Reference citation should not appear in the abstract. Authors should always remember that the abstract is the first part read by reviewers, so it should be clear and simple. A good abstract is usually followed by a good paper. Although the abstract appear first in the paper, it is usually the last section when writing the paper. To have a good abstract, read it at several time on different occasions. Surey you will modify it every time you read it. Abstracts should not exceed 250 words (sometimes 200 words). Therefore, remove all unnecessary words and always keep it simple. In most modern indexing systems, the abstract appear together with the title, so, make sure that it is prepared in a format acceptable for electronic indexing. Abstracts should be written in the past tense because it refers to work done.

How to write the Introduction

The introduction is the first part of the actual paper. It is a wise policy to begin writing the paper while the work is still in progress. This makes the writing easier because every thing is still fresh in mind. Moreover, the writing it self may unveil inconsistency in the results or suggest an interesting sideline that might be followed.
The purpose of the introduction is to supply sufficient background information to allow the reader to understand and evaluate the results without the need to refer to previous publications. It should also provide rationale for the present study and state clearly and briefly the purpose of the paper. The introduction should be written in the present tense because you will be referring primarily to the problem and the established knowledge relating to it at the start of your work. A good introduction should (1) present first, with all possible clarity, the nature and scope of the problem investigated, (2) should review the pertinent literature to orient the reader, (3) state the method of the study and the reason for choosing a particular method, (4) state the principle results of the investigation, and (5) state the principle conclusion(s) suggested by the results. A usual mistake by many authors is to keep the best for the last. Authors should not keep the reader in suspense. Let the reader follow the development of the evidence. In the introduction the author should have a hook to gain the readers attention. Why did you choose that subject? Why is it important? The literature review and choice of methods should be presented in such a way that a reader will understand what the problem was and how you attempted to resolve it. The principle results and conclusions should be the capstone of the introduction. When writing the introduction keep in mind that your paper may be read by people in other specialties. Therefore, provide them with all necessary background to understand what is coming next.

How to write the Materials and Methods

In the first section of the paper (introduction) you justified the use of a specific method and may also defended the reason for your choice. Now, in this section, you must give full details of the method. Most of this section should be written in the past tense. The main purpose of the section is to describe the experimental design and then provide enough detail that the competent worker can repeat the experiment. Many reader will skip this section because the already know, from the introduction, the method that you used and are not interested to know the experimental details. However, careful writing of this section is critically important because the cornerstone of the scientific method requires that your results, to be of scientific merit, must be reproducible. A good reviewer will read the materials and methods carefully. If there
is serious doubt that the experiment could be repeated, the reviewer will recommend the rejection of the manuscript no matter how well the results.

When writing this section, the author should include the exact technical specifications and quantities and source or method of preparation. Use of trade names should be avoided. Generic or chemical names are usually used in this section. However, if there is a known difference among different products and if this difference is critical, then the trade name and dealer details should be provided. Experimental animals, plants, and microorganisms should be identified accurately. Source and special characters (age, sex, genetic and physiological status) should be described. The materials and methods section should be considered similar to cookbook recipes. Questions such as “how” and “how much” should be precisely answered by the author. A major fault in this section is to mix some results into it. Results should not be stated in this section, but, in the results section.

**How to write the Results**

The whole paper may stand or fall on the basis of the results. This section should not start by describing the methods that you already stated in the materials and methods section. The result section usually has two important ingredients. First, it should give some kind of an overall description of the experiment providing the big picture without repeating the experimental details stated in the materials and methods section. Second, it should present the data. When writing this section, the past tense is usually used.

When the results are represented in the form of numbers, an appropriate representation system should be used. If one or few determinations are to be presented, they should be described in the text. If too many numbers are to be represented they should be described in tables or graphs. Appropriate statistics should be used to defend this section. The choice of an appropriate statistical test is very critical. Many manuscripts have been rejected because the applied statistical analysis was not the appropriate one for the study.

Results should be short and sweet. If you are out to describe the truth, leave elegance to the tailor. Authors should avoid redundancy and verbose sentences in citing tables. Authors should never use words that show the intention of polishing their results. Reviewers are usually aware of such phrases and will become so annoyed when
seeing such phrases. This might lead to the rejection of a manuscript describing unique work with excellent results.

**How to write the Discussion**

The discussion is the hardest section to write. Many papers have been rejected because of a faulty discussion, even though the data might be valid and interesting. When writing a discussion, be careful not to show the real truth from the first line. In the discussion section you should give answers to all questions raised in the paper. Some authors go round and round to cover up their inability to answer such questions. Readers of the paper usually strive for such answers. To write a good discussion you should:

1. Try to present the principles, relationships, and generalizations shown by the results. Keep in mind that you are discussing and not repeating the results.
2. Point out any exceptions or any lack of correlation and define unsettled points. Never take the risk of trying to cover data that do not quite fit.
3. Show how your results and interpretations agree (or contrast) with previously published work.
4. Don’t be shy. Discuss the theoretical implications of your work as well as all possible practical applications.
5. State your conclusion as clearly as possible and summarize your evidence for each conclusion.

In the discussion, use the present tense to describe other people’s work and the past tense to describe your own results. The primary purpose of the discussion is to show the relationship among observed facts. Sometimes the significance of work is not discussed or not discussed adequately. This will lead to a reader asking him/her self “so what?” the discussion should end with a short summary or conclusion regarding the significance of the work.

**How to state the acknowledgment**

For the acknowledgment, two possible ingredients require consideration. First, you should acknowledge any significant technical help that you received from any individual. You should also acknowledge the source of special equipments and other
materials that you used in the study. Second, you should acknowledge the outside financial assistance such as grants, contracts, and fellowships.

**How to cite the references**

A manuscript containing innumerable references is more likely a sign of insecurity than a mark of scholarship. Authors should only cite or list significant published references. In some cases it is accepted to cite references to unpublished data or papers in press. There are different styles in listing the references. It is advisable to consult a recent issue of the journal you intend to publish in or check the instructions to authors.

**How to design effective tables**

Tables should only be used if repetitive data is to be presented. Whenever a table, or columns within a table, can be put into words it's better to write them as a text. When presenting numbers, only significant figures should be used. Using non-significant figures may mislead the reader or create a false sense of precision. They also make comparison of data more difficult.

If you decided to use a table then arrange the table in a way that the like elements should read down and not across. This will allow the reader to grasp the information more easily and is usually less compact making it less expensive in printing.

Avoid using exponents in table because of the confusion they create when reading them. Titles of tables should be concise and should reflect the content of the table. Tables should be made in a camera ready format since many journals scan or photocopy them and treat them as images.

**How to design effective illustration**

The golden rule here is to use illustrations only if it is necessary. If the results of the figure can be described in words, then it should be written in a text form and not made into a figure. Figures are considered as pictorial tables. If you are confused whether to
use table or graphs then check first what you want the reader to know. If you want the reader to know the exact numbers then use tables. If you want the reader to have a general ideas about the whole picture then use figures.

It is advisable to use computer graphic software to develop graphs. Graphs developed on lined graph paper will usually show a shadow of the lines when photocopied. Moreover, graphs should be prepared in a form suitable to withstand reduction. As for tables, graphs should be made in a camera ready format since many journals scan or photocopy them and treat them as images. Both graphs and table should be attached to a hard paper to arrive at the publisher end in one piece. If using several lines in a graph, use well defined symbols to differentiate between them. Don’t use colors unless it is really necessary.