

Chapter 08

WRITING SCIENTIFIC PAPER

A good scientific paper should leave an impact on the reader. It should describe significance of the project, objectives of the study, methodology employed and the results. Various components of a research article, and when and how each section should be written are described.

8.1 INTRODUCTION

An acceptable primary scientific publication must be the first disclosure containing sufficient information to enable the peers to assess, observe, repeat experiments, and evaluate intellectual processes. Moreover, it must be susceptible to sensory perception essentially permanent, available to the scientific community without restriction and available for regular screening by one or more of the major recognized secondary services (for example: Biological Abstracts, Chemical Abstracts, Index Medicus, Excerpta Medica, Bibliography of Agriculture, Veterinary Bulletin, etc.).

8.2 WRITING SCHEDULE

To meet the requirements of the above definition, it is essential that a scientific paper must be original work, written in a specific format with all simplicity and clarity. Hence, it is wise to start writing the paper while the work is still in progress. This makes the writing easier because everything is fresh in mind. Furthermore, the writing process itself is likely to point inconsistencies in the results or it may suggest some other lines that might be followed.

There is no hard and fast rule as to which part of the paper should be attempted first, and which part be written last. Since the approach is to write the paper while work is in progress, start with the section one finds easy. Experience has shown that Materials and Methods is the easiest to write and should be written first. Introduction is more difficult to write because there are several approaches to it. Parts of Introduction may be written simultaneously since significance of the

project is in mind and the study has to be based on certain objectives. Results can only be described when research work is completed. Literature cited can be compiled simultaneously, especially if one is working with a computer. Abstract should be the last portion to be written. The requirements for writing various sections of a research paper vary, especially with regard to citing and listing references. These must be followed strictly, if prompt action is desired by editor of the journal to which the article will be submitted for possible publication.

8.3 FORMAT OF A RESEARCH PAPER

The most acceptable format of a research paper is IMRAD (Introduction, **M**ethods, **R**esults and **D**iscussion). In question form, IMRAD can be stated as:

- What question was studied? The answer is the Introduction.
- How was the problem addressed? The answer is the Methods.
- What were the findings? The answer is the Results.
- What do these findings mean? The answer is the Discussion.

8.3.1 TITLE

Title of a publication is the most read item either in the original journal or in abstracting or indexing services. It is a label and not a sentence. Hence, all words must be selected with great care and their association with each other must be carefully managed. A good title is composed of fewest possible words that adequately describe the contents of the paper. The meaning and order of the words are of importance to potential readers who see the title in the journal Table of Contents. It also should be in a form suitable for machine indexing systems used by the abstracting services (Chemical Abstracts, Index Medicus, Food Science and Technology Abstracts, and others). The terms in the title should be limited to those words that highlight significant content of the paper and are both understandable and retrievable. Key words should be extracted from the title. The title should preferably have no abbreviations. Use of superfluous words such as "Studies on", "Investigations on", "Effect of", "Observations on," "Role of," and others, should be avoided.

8.3.2 ABSTRACT

Abstract is the first part of an article and is the most read after title. It serves as a screening device to give readers an idea of what the article as a whole is about. In journals, it helps readers decide whether to read the whole paper or not. When published separately in outlets such as Websites and secondary indexing journals, it is viewed by more people who will read the Abstract only. Hence, it must contain all important aspects discussed in the paper.

Types of Abstracts

Abstracts are of two types: informative and indicative.

- a. The **informative** abstract (also called substantive abstract) is useful for research articles where the report is based on lab work. It should follow the IMRAD format. It should state the importance, principal objectives and scope of the investigation (Introduction), describe the methodology employed (Materials and Methods), summarize the results (Results) and state the main conclusions.
- b. The **indicative** or descriptive abstract is useful for review papers, conference reports, government reports and other similar publications. It is designed to indicate the subject of a paper, making it easy for potential readers to decide whether to read the paper or not. Such indicative abstracts are often of great value to reference librarians.

A meeting abstract, informative or descriptive, is a requirement for participation in national and international meetings. In some conferences acceptance for participation is sometimes determined on the basis of submitted abstracts. Hence, scientists should master the fundamentals of Abstract preparation.

Since the Abstract will be published by itself (on Websites or by indexing journals), it should be self-contained. It should include no bibliographic, figure, or table references. The language should be familiar to the potential reader. Obscure abbreviations and acronyms should be omitted. It is a miniature version of the paper and sometimes the only part to be read. Therefore, it must be written clearly and simply. It should be written as a single paragraph, usually not exceeding 250 words. Some journals require that abstract be split in headings, similar to the paper – introduction, objectives, methodology, results, and conclusions. It is preferably written after the paper has been completed.

8.3.3 INTRODUCTION

Introduction is the first section of the proper text. It must answer "what question was studied? It does not have a specific structure and any approach that puts facts and ideas in order is acceptable. Its purpose is to supply sufficient background information to allow readers to understand and evaluate the results without needing to refer to previous publications on the topic. It should start with a broad context of the study and lead to the objectives, hypothesis or the question to be investigated. The Introduction should answer why the topic was chosen and why it is important. This section should provide rationale for the present study and state clearly purpose and scope of the problem. The level of the audience must be kept in mind so as to determine the terms and procedures that need defining or describing. It is the proper place to define any specialized terms or abbreviations that are to be used.

The most recent work in the subject area must be reviewed in this section to find out what is known about the problem. This prevents re-inventing the wheel. It should be designed to summarize, analyze, evaluate, or synthesize information that has already been published so that new syntheses, new ideas and theories can be formulated. For a good Introduction, relevant facts from scientific literature must be chosen. These should be paraphrased and reassembled into a logical sequence. The source must be cited at that point in the sentence to which it applies to support the statement. References must be chosen carefully to provide most important background information.

Most part of the Introduction should be written in the present tense, since the problem and established knowledge relating to it are being referred.

8.3.4 MATERIALS AND METHODS

This section consists simply of factual statements indicating how the proposed study was conducted and what materials were used for this purpose. This section should be able to answer the question "how was the problem addressed"? The main purpose of this section is to describe and, if necessary, defend the experimental design. The method of investigation with reasons for selection of a particular technique, if required, must be stated. The choice of methods should be presented in such a way that the reader will understand how the problem was attempted. Careful writing of this section is critically

important because the cornerstone of scientific method requires that the results must be reproducible.

The Materials should include exact technical specifications, quantities and source or method of preparation. Sometimes, it is necessary to list pertinent chemical and physical properties of the reagents used. Avoid use of trade names; generic or chemical names are usually preferred. Where trade names are to be mentioned, then state the manufacturer as well. For materials, the usual order of presentation is chronological. However, related methods should be described together and straight chronological order may not always be followed.

In describing methods of investigation, sufficient details should be given so that a competent worker could repeat the experiments, whether mentally or practically. The methods should be precise. For example, if a reaction mixture was heated, give heating temperature and duration. Questions such as "how" and "how much" should precisely be answered by the author and not left for the reader. If the method is new and unpublished, then all necessary details must be provided. Approved methods of AOAC, AOCS, ACCS or others should be referred with their numbers. It is not sufficient to say "oil content was determined as described in AOCS (1997)". The proper way is to say "Oil content was determined according to official method No. Af 3-54 (AOCS 1997)." Where several alternate methods are employed, it is useful to identify the method briefly as well as to cite the reference. Where a modified method was used, there is a need to specify how it differed from the original method.

Materials and Methods is the first section of the paper in which subheadings should be used. When possible, construct subheadings that "match" those to be used in Results. The writing of both sections will be easier if an internal consistency is strived. The reader will be able to grasp quickly the relationship of a particular methodology to the related results.

Most of this section should be written in the past tense.

8.3.5 RESULTS

The Results section should be written when graphs and tables are ready. It should start with overall description of the experiments, providing a broad picture without repeating the details already mentioned in Materials and Methods section. Most representative data should be presented but facts must be selected. Variables that do not seem to affect need not be tabulated or presented. However,

it is often important to define even negative aspects of the experiment. It is good to state what could not be found under the conditions of the experiment.

Although Results section of a paper is the most important part, it is often quite short, particularly when it is preceded by a well-written Materials and Methods section followed by a well-written Discussion. There is no need to be verbose in citing figures and tables. Graphs and tables present data, they do not state results. Instead of saying "it is clearly shown in Table 1 that vitamin C decreased in", it is preferable to say "vitamin C decreased in (Table 1)".

The results need to be described clearly and simply, because they comprise new knowledge that is being contributed. The earlier parts of the paper (Introduction, Materials and Methods) are designed to tell why and how the results were obtained. The later part of the paper, Discussion, should reflect what the results mean. Therefore, the whole paper must stand or fall on the basis of the results. All graphs and tables must have appropriate captions that describe the data. The captions are written underneath graphs and on top of the tables. The words "table", "figure" and "plate" must be written with the first letter capital, for example, Table 4, Fig. 2, Plate 5. The Results section should be presented in the past tense.

Statistical analyses are often necessary, but data should be featured and, not the statistics. The probability levels used to substantiate statistical significance should be mentioned. There is no need to state exact values of a test statistic (e.g. t-values, F-ratios), or present analysis of variance tables, or state degree of freedom for each test. In analysis-of-variance (ANOVA), explicitly state the factors in the model. Estimates of variability such as standard deviation, standard error of the mean or interquartile range must be given. Standard statistical abbreviations must be used.

8.3.6 DISCUSSION

The Discussion answers the question: "What do the results mean"? It is essentially an argument about the objectives or hypothesis based on the results. Since all experiments or observations relate to the hypothesis in question, conclusions must be drawn at the end. The Discussion part should answer the reliability of the data, whether there had been significant sources of error or not, and whether the results support the hypothesis or not. Furthermore, results must be interpreted in the light of the hypothesis and published literature.

Even changes in procedures may be discussed that would have given better results.

The Discussion starts by interpretation of the facts in a positive way. The results must be assessed by taking problems and errors into account. The data obtained should be compared or contrasted with the theory and data from literature. In so doing, experimental designs should also be considered. The Discussion may be finished by drawing conclusions and relating them to the Introduction. If appropriate, suggestions may be made on how to improve the experiment or what additional experiments would be helpful. The reader should be left with a positive message.

8.3.7 REFERENCES

The practice of quoting references is a matter of ethics, but the method of citing is a craft. Therefore, manuscript should be checked before its submission and again at the galley proof stage that all parts of every reference are correct. There are far more mistakes in the References section of a paper than anywhere else.

Only significant published references cited in the text should be listed. These must substantiate, relate to, or confirm the assumptions in the study. References to unpublished data, papers in press, abstracts, theses and other secondary materials should be avoided. Complete details of the references should always be collected. These include author(s), year of publication, title, journal, volume, issue number, and inclusive pages. The use of inclusive pagination (first and last page numbers) is required by many journals.

The use of abbreviations aspect of reference citation has been standardized. Almost all major primary journals and secondary services use the same system of abbreviation. The word Journal is now always abbreviated "J." All "ology" words are abbreviated at the "l" (Microbiology as "Microbiol" and "Biotechnology" as "Biotechnol"). One-word journal titles such as Nature, Science, Biotechnology, are not abbreviated. Hence, follow the journal guidelines for submitting articles.

8.4 GETTING YOUR PAPER PUBLISHED

After completing the research, it must be published otherwise all the resources are wasted. The author must ensure that the work adds to the existing knowledge and is of interest to the scientific community in that particular discipline. While preparing the manuscript one must make sure that it meets the editorial requirements of the journal – this means go through the instructions to authors and have a look at

a few latest issues. Especially important is the reference style, spacing, line numbering, etc. It is worthwhile to get the paper reviewed by a few friends or seniors before sending it for publishing. Most journals now require that the paper be submitted electronically. Some also require one or two hard copies as well. The manuscript must accompany a forwarding letter and submitted with the consent of all authors.

When the manuscript is received by the editor of the journal, he makes a preliminary evaluation, especially looks at the style and format. If it conforms to that of the journal then he sends it to one or two referees for technical evaluation. The editor sends an acknowledgement to the corresponding author. The referees review the manuscript and give their comments that may be favourable or unfavourable. Quite often referees suggest changes that improve the quality of the paper. Rejected manuscripts may have a poor experimental design and analysis, or inappropriate techniques have been used or the work may not be new or substantial enough. Poor presentation and poor interpretation are also important in forcing referees to reject the manuscript.

The journal for publishing the paper must be selected based on its reputation and quality of papers published. The journals are rated on the basis of "impact factor" – higher the impact factor better is the journal since it is read and referred by more scientists. The impact factor is calculated using the following formula:

$$\text{Impact factor for 2018} = \frac{\text{Citations in 2018 to papers published in that journal in 2016 + 2017}}{\text{no. of papers published in that journal in 2016 + 2017}}$$

8.5 POCKET GUIDE FOR RESEARCH PAPERS

TITLE – Use brief, concise, meaningful words. Don't start with "Effects of", "Study of", "Role of", "Investigations in" and other such phrases. Finalize the title after the manuscript is finished.

ABSTRACT – Use brief statements of nature of problem, hypothesis, general approach, results and conclusions. Limit to 100 - 150 word.

INTRODUCTION – Briefly describe the importance, nature of problem, what has been done before, how this approach differs, remaining problems, your hypothesis and the objective of the current study.

MATERIALS AND METHODS – State what you did and how you did it in such a way that a reader can repeat the study. Do not include discussion, rationale, excuses and others. Describe methods used for statistical analysis.

RESULTS AND DISCUSSION – What did you find? How do results relate to those reported previously? Was your hypothesis correct? Does it need to be changed? Are all tables, graphs and other illustrations absolutely necessary to understand the study? Is information in tables, graphs and text redundant or repetitive? Are statistical differences/significances clear?

CONCLUSIONS – Answer the question, "So what?" What recommendations/advice to other researchers and end users can be made on the basis of your findings? Do you need to adapt your hypothesis or extend it? Do not state, "More research needs to be done."

REFERENCES – Are format, details of listing, sequence and other details in accordance with the style of the journal in which the paper is being submitted? Have all the references cited in the text listed?

GENERAL – Did you follow the style guide of the journal in all aspects of manuscript preparation? Did you submit the required number of copies?

Adapted from Berry and Noyes (1993).