

# WRITING A SCIENTIFIC PAPER

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## ABSTRACT

Scientific paper is the outcome of hard labour done over a period of months on a certain topic by scientists or students for their postgraduate degree. A good paper should leave an impact on the reader. It should describe the significance of the project, objectives of the study, methodology employed and the results. This paper describes various components of a research article, and when and how each section should be written.

**KEY WORDS:** Research paper, Title, Abstract, introduction, Methods, Results, Discussion, Bibliography.

## INTRODUCTION

An acceptable primary scientific publication must be the first disclosure containing sufficient information to enable the peers to assess, observe, to repeat experiments, and to evaluate intellectual processes<sup>1</sup>. 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, and similar services).

It is essential that a scientific paper must be original work, written in a specific format with all simplicity and clarity to meet the requirements of the above definition. 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 the mind. Furthermore, the writing process itself is likely to point to inconsistencies in the

results or it may suggest some sidelines that might be followed. One must have a clear purpose in mind.

There is no hard and fast rule that the first part of the paper should be written first, and the last part written last. Since the approach is to write the paper while work is in progress, it is best to start with the section one finds easy. Materials and Methods, experience has shown, 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 the significance of the project is in mind and the objectives are being investigated. Results can be written only when research work is completed. Literature cited can be compiled simultaneously, especially if one is working on the 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 for

prompt action by the editor of the journal to which the article will be submitted for possible publication. Some essentials for writing each section of a scientific paper are described in this paper.

## FORMAT OF A RESEARCH PAPER

The most acceptable format of a research paper is IMRAD<sup>2</sup> (Introduction, Methods, Results and Discussion). In question form, IMRAD can be stated as: What question was studied? The answer is the Introduction. How was the problem addressed<sup>9</sup> The answer is the Methods. What were the findings? The answer is the Results. What do these findings mean? The answer is the Discussion.

### 1. TITLE

Title of a publication is the most read item either in the original journal or in abstracting or indexing services<sup>3</sup>. 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 the 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" and others, should be avoided.

### 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 examine the whole paper or not. When published separately in outlets such as Websites and secondary and indexing journals, it is viewed by many more people. Most will read the Abstract only. Hence it must contain all important aspects of the paper.

Abstracts are of two types: informative and indicative<sup>3</sup>. The informative abstract (also called substantive index) 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 principal conclusions. 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.

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. It is preferably written after the paper has been completed.

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.

### 3. INTRODUCTION

Introduction is the first section of the text proper. 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 the reader 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 define the problem and describe its importance. 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<sup>4</sup>. 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 statements<sup>5</sup>. References must be chosen carefully to provide the most important background information.

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

### 4. MATERIALS AND METHODS

This section consists simply of factual statements of what materials were used, what was done with them and how the study was conducted<sup>6</sup>. 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

necessary, 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<sup>2</sup>.

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. In case of drugs, the generic name, dose and route of administration must be given<sup>7</sup>. Where trade names are to be mentioned, then state the manufacturer as well. For materials, the usual order of presentation is chronological. Obviously, however, related methods should be described together and straight chronological order may not always be followed. In describing the 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. If a reaction mixture was heated, give the temperature. Questions such as "how" and "how much" should be precisely 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 or established methods such as those 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. The 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.

Statistical analyses are often necessary, but data should be featured and, not the statistics. Ordinarily statistical method should be used without comment; advanced or unusual methods may require a literature citation. Most of this section should be written in the past tense.

## 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 the Results section of a paper is the most important part, it is often the shortest, 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 stored apples" it is preferable to say "vitamin C decreased in stored apples (Table 1)".

The results need to be clearly and simply stated, because it is the Results that 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, tells 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 word capital, for example. Table 4, Fig. 2, Plate 5.

If statistics are used to describe the results, they should be meaningful. The Results section should be presented in the past tense.

## 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, the conclusions must be drawn in 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, the results must be interpreted in the light of the hypothesis and the published literature. Even changes in procedures may be discussed 'hat would give better results.

The Discussion starts by interpretation of the facts in a positive way. The results must be assessed and problems and errors taken into account. The data obtained should be compared or contrasted with the theory and data from literature. In so doing, experimental designs should 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.

## 7. REFERENCES

Journals vary considerably in their style of handling references. Most journals cite references in either the name-year or citation-sequence styles<sup>8</sup>. 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 "I" (Microbiology as "Microbiol" and "Biotechnology" as "Biotechnol"). One word journal titles such as Nature, Science are never abbreviated<sup>8</sup>. Hence, follow the

journal guidelines for submitting articles.

Only significant published references should be listed. References to unpublished data, papers in press, abstracts, theses, and other secondary materials should be avoided. If such a reference seems absolutely essential, it may be added parenthetically or as a footnote in the text. Complete details of the references should always be collected. These include author(s), year of publication, title, journal, volume, issue number, inclusive pages<sup>9</sup>. The use of inclusive pagination (first and last page numbers) is required by many journals. The 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.

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