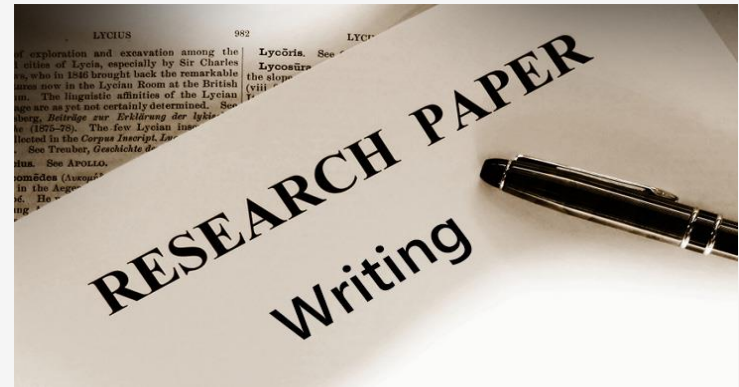


HOW TO WRITE A SCIENTIFIC PAPER



What is a Scientific Paper ?

- a scientific paper is a written and published report describing original research results

Why to write (and publish) a Scientific Paper ?

- the purpose of scientific writing is to communicate new scientific findings
- a scientific experiment is **not completed** until the results **have been published** and **understood**
 - scientist must not only "do" science but must "write" science
 - no matter how spectacular the results are, the work is not completed until the results are published
- “a naturalist’s life would be happy one if he had only to observe and never to write” (Charles Darwin)

Importance of Scientific writing

- writing a scientific/research paper can be daunting task!
- although *good writing* does not lead to the *publication of bad science*, **bad writing** can and often does **prevent or delay** the **publication of good science**
 - even with groundbreaking research, unless the paper is correctly written:
 - at best, publication will be delayed
 - at worse, never published
- the outcome (i.e. scientific paper) has to be clear, simple and well ordered to reflect the new scientific findings, as well as to be understood by readers
- scientific writing must use proper language (mostly English; accepted as a language of science) which gives the sense in the fewest short words

Historical overview

knowledge would be lost without written records

Where to write?!

- it started with cave paintings and inscriptions as first attempts to leave records on some knowledge, skills and experience
- in ancient Egypt, papyrus paper was used as a medium of communication, although they used inscriptions in stones as well (i.e. pyramids)
- after Chinese invented the paper (cca. 100 AD) – new communication tool

Historical overview (continued)

knowledge could not be widely circulated with no effective production and distribution

1st breakthrough point

- invention of movable type (old China, 1100) and its application in copying books (Guttenberg, 1455)
- first scientific journals published in 1665 – articles written in a form of descriptive papers
- modern layout of scientific papers; 2nd half of 19th century
 - more dedication to reproducibility of experiments as fundamental principle of science philosophy
 - methods section became highly important since Louis Pasteur and its confirmation of the germ theory

2nd breakthrough point

- invention of world-wide-web (1989) – enabling of knowledge spreading all-over the world

Types of written communications

- **Reports**
 - project, grant, laboratory, department...
- **Theses or dissertations**
 - BSc, MSc or PhD
- **Journal articles**
 - research papers, review papers, short communications
- **Books and book chapters**
 - scientific or educational
- **Technical manuals/users guides**
- **Research or grant proposals**
 - *extremely important* – resources/funding for research
- **Slide presentations**
 - conferences, invited talks, project/grant disseminations...
- **Posters**
 - conferences

Types of journal papers

- **original research articles**

- most popular, most spread, requires: experimental / computational work, critical thinking

- **review articles**

- mostly published by invitation or in specific targeted journals, require critical thinking and field of interest survey, no experimental or computational work

- **short communications**

- accepted by most journals, similar to research papers, but restricted with the number of words and results presented – enable fast publication of some breakthrough results

- **letter to the editor**

- sent to a publication about issues of concern from its readers, communicate some raised issue in particles publication by the journal

Structure of research paper "IMRaD" format

- **I** = Introduction
 - what question (problem) was studied, what others and you did?
Short survey on study area of interest
- **M** = Methods
 - how was the problem studied
- **R** = Results
 - what are the findings
- **a** = and
- **D** = Discussion
 - what do these findings mean

Definition of scientific paper

An accepted original scientific publication containing scientific information to enable peers:

1. to assess observations
2. to repeat experiments
3. to evaluate intellectual processes
4. must have an impact
5. available to scientific community without restriction
6. available for regular screening by one or more of the major recognized secondary services (on-line bases; Pub Med, Scopus, etc...)

Before you start

Be aware of key elements of publishing

- Ethical Issues
- Style and language
- Structure of paper
- Components of paper
- Article submission process/journal selection
- Publisher's process/peer review

Before you start

Ethical issues

- Disclosure of Conflict of Interest
- Acknowledgment of funding sources
- Image manipulation guidelines
- Online submission - supplemental information
(datasets, videos)

Before you start

Style and language

- refer to the journal's author guide for notes on style
 - some authors write their paper with a specific journal in mind
 - others write the paper and then adapt it to fit the style of a journal they subsequently choose
- objective is to report your findings and conclusions clearly and concisely as possible
- if English is not your first language, find a native English speaker (if possible) to review the content and language of the paper before submitting it
- regardless of primary language, find a colleague/editor to review the content and language of the paper

Before you start

Be aware of essential parts of a scientific paper

- **Title**: Describe concisely the core contents of the paper
- **Abstract**: Summarize the major elements of the paper
- **Introduction**: provide context and rationale for the study
- **Materials**: Describe the experimental design so it is reproducible
- **Methods**: Describe the experimental procedures
- **Results**: Summarize the findings without interpretation
- **Discussion**: Interpret the findings of the study
- **Conclusions/Summary**: Summarize the findings
- **Acknowledgement**: Give credit to those who helped/funded you
- **References**: List all scientific papers, books and websites that you cited

Before you start

- to have a (quality) results!!
- make tables
- draw graphs
- summarize each table/figure in a single sentence
- share your tables/figures and single-sentence summaries to coauthors
- make additional notes; record summaries of results and any observation although seems insignificant
- date the files – important to avoid confusing with the versions
- revise your readings – maybe there is a need to repeat some experiment
- write any ideas (related to the conducted research) when ever they come to you – **24h thinking!!**

Before you start

- make a literature survey on the field of interest
- review your results and notes again
- choose a journal – on the basis of conducted survey and your results

- **Strategies to choose the journal**
 - Where many of the papers cited were published?
 - Where do cited scientists publish their work?
 - Read the advertising statements of journals
 - Read the “scope” paragraph
 - Read the table of contents of potential journals
 - Examine several articles in potential journals

Before you start

Author Publishing Priorities

- quality and speed
 - top items:
 - refereeing speed
 - refereeing standard
 - journal reputation
- editor/board, physical quality and publication services

Where to submit the manuscript

- The prestige factor
- The circulation factor
- The frequency factor
- The audience factor

Before you start

Who can publish your paper?

○ Professional societies

- ACS
- RSC
- IWA
- ASCE
- ...

○ Professional publishers

- Elsevier
- Springer Verlag
- Wiley & Sons
- Kluwer Academic Publishing
- Blackwell
- Taylor & Francis
- Hindawi
- Academic Press

Paper organization

Title

- a good title is defined as the fewest possible words that **adequately describe** the contents of the paper
- the title is extremely important and must be chosen with great care as it will be read by thousands, whereas few will read the entire paper
- indexing and abstracting of the paper depends on the accuracy of the title
 - an improperly titled paper will get lost and will never be read

Paper organization

Title (continued)

- titles should neither be too short nor too long as to be meaningless
- waste words (*studies on, investigations on, a, an, the* etc) should not be used
- syntax (word order) must be very carefully considered
- it should contain the keywords that reflect the contents of the paper
- it should be meaningful and not general
- it should be concise, specific and informative
- it should capture the fundamental nature of the experiments and *findings*

Paper organization

Title (continued)

How to Prepare the Title

- make a list of the most important keywords
- think of a title that contains these words
- the title could state the conclusion of the paper
- the title **NEVER** contains abbreviations, chemical formulas, proprietary names or jargon
- think, rethink of the title before submitting the paper
- be very careful of the grammatical errors due to faulty word order

Paper organization

Abstract

- an abstract can be defined as a summary of the information in a document
- it is of fundamental importance that the abstract be written clearly and simply, as it is the first and sometimes the only part of the manuscript read.
- it should provide a brief summary of each of the main sections (IMRaD) of the paper:
 1. *State the principal objective and scope of the investigation*
 2. *Describe the methods used*
 3. *Summarize the results, and*
 4. *State the principal conclusions*
- it is easier to write the abstract after completion of the paper

Paper organization

Abstract (continued)

Criteria of the Abstract

- usually, it should not exceed 250 words (depending on journal publisher rules)
- it should be written in one paragraph.
- it should be written in the past tense as it refers to work done
- long words should be followed by its abbreviation which would be used through out the abstract (and paper)
- it should not cite any references (except in rare cases)
- it should never give any information or conclusion that is not stated in the paper
- must be accurate with respect to figures quoted in the main text.

Paper organization

Introduction

- **the introduction should answer the following questions:**
 1. What was I studying?
 2. Why was this an important question?
 3. What did I know about this topic before I did this study?
 4. What model was I testing? and
 5. What approach did I take in this study

Paper organization

Introduction (continued)

Suggested rules for a good introduction:

- it should present the nature and scope of the problem investigated
- provide background and present the review the pertinent literature
- list the structure of your research project and what you plan to present in your paper
 - state the method of investigation
 - state the principal results of the investigation
 - state the principal conclusion(s) suggested by the results

Paper organization

Introduction (continued)

General rules

- use the present tense when referring to work that has already been published, but past tense when referring to your own study
- use the active voice as much as possible
- avoid lengthy or unfocused reviews of previous research
- cite peer-reviewed scientific literature, avoid general reference works such as textbooks, but might be used with specified pages reflecting stated
- define any specialized terms or abbreviations

Paper organization

Introduction (continued)

Tips

- 2-3 paragraphs, <450 words
 - ***First paragraph***
 - introduce broad area
 - ***Second paragraph***
 - explicit rationale
 - ***Last paragraph***
 - hypothesis

Paper organization

Materials and Methods

- complete information of materials and methods used, conditions present, actions, experimental design, etc.
- this section usually has subheadings; when possible match those to be used in Results
- enough information must be given so that the models/experiments can be reproduced
- ask a colleague if he/she can follow the methodology

Paper organization

Materials and Methods (continued)

Tips

- provide full details so that the experiments are reproducible
 - if the peer reviewer has doubts that the experiments could be repeated, the manuscript will be rejected
- organize the methods under subheadings, with related methods described together (e.g. *Materials, Experimental procedure, Analysis, Calculations, Computational procedure...*)
- describe the experimental procedure/design in detail
- do **not** mix some of the Results in this section
- write in the past tense

Paper organization

Materials and Methods (continued)

Materials

- must identify accurately experimental chemicals, materials, animals, plants, microorganisms... (*technical and natural sciences, medical papers*)
- the source of subjects studied, number of individuals in each group used, their sex, age, and weight must be clearly stated (*social and human science, medical papers*)
- for chemicals used, include exact technical specifications (purity, producer/supplier name & country) and source or method of preparation
- avoid the use of trade names of chemicals; generic or chemical names are preferred

Paper organization

Materials and Methods (continued)

Methods

- this part of the manuscript must be clear, precise and concise so that it can be reproducible
 - if the method is new, *all* details must be provided
 - if the method has been previously published in a scientific journal, only the reference should be given with some short identification
- questions such as “how” or “how much” must be answered and not left to be puzzled over
- methods used for statistical analyses must be mentioned; ordinary ones without comments, but advanced or unusual ones require literature citation

Paper organization

Results

- display of data with logical development showing how your findings satisfy your objectives
- where possible give illustrative examples and compare those with known results from literature
- use tables and figures

Paper organization

Results (continued)

How to write the Results

- section is written in the past tense
- it is the core or heart of the paper
- it needs to be clearly and simply stated since it constitutes the new knowledge contributed to the world
- the purpose of this section is to summarize and illustrate the findings in an orderly and logical sequence, without interpretation
- the text should guide the reader through the findings, stressing the major points
- do not describe methods that have already been described in the **M&M** section

Paper organization

Results (continued)

Methods of presenting the data

1. **directly in the text**
 2. **in a table**
 3. **in a figure**
- all figures and tables **must** be accompanied by a textual presentation of the key findings
 - never have a table or figure that is not mentioned in the text
 - refer to data (Fig. X, Table Y)
 - don't repeat numbers in Tables
 - can state numbers from Figures if precision is required
 - a lot of numbers? make Table

Paper organization

Results (continued)

Tables and figures

- Tables are appropriate for large or complicated data sets that would be difficult to explain clearly in text.
- Figures are appropriate for data sets that exhibit trends, patterns, or relationships that are best conveyed visually.
- any table or figure must be sufficiently described by its title and caption or legend, to be understandable without reading the main text of the results section.
- do not include both a table and a figure showing the same information

Paper organization

Discussion

- it is the hardest section to write
- often combined with the Results section into one section: *R&D section – core of paper*
- its primary purpose is to show the relationships among observed facts
- it should end with a short summary or conclusion (depending on journal publisher rules) regarding the significance of the work
- conclusions often extracted into separate section ending the paper; *Conclusion*

Paper organization

Discussion (continued)

Components of the discussion

- try to present the principles, relationships, and generalizations shown by the Results
- point out any exceptions or any lack of correlation and define unsettled points
- show how your results and interpretations agree or contrast with previously published work
- discuss the theoretical implications of your work, and any possible practical applications.
- state your conclusions as clearly as possible
- summarize your evidence for each conclusion

Paper organization

Discussion (continued)

Tips

○ *First paragraph*

- state major findings
- paraphrase abstract

○ *Last paragraph*

- “In summary...” (2-3 sentences)
- “In conclusion...” (biggest message, return to Intro, avoid speculation, avoid “need more work”)

○ *Middle paragraphs*

- base each on a major result
- always focus on **your** results
- never discuss prior work without reference to **your** work
- refer to Tables and Figures

Paper organization

Conclusions

- state your conclusion(s) as clearly as possible
- summarize evidence for each conclusion
- end with a short statement regarding the significance of your work

Paper organization

Acknowledgments

- you should acknowledge:
 1. any significant technical help that you have received from any individual in your lab or elsewhere
 2. the source of special equipment, cultures, or any other material
 3. any outside financial assistance, such as grants, contracts or fellowships
- do not use the word “wish”, simply write “I thank ...” or “I acknowledge...” and not “I wish to thank...”
- show the proposed wording of the Acknowledgement to the person whose help you are acknowledging

Paper organization

References

What is referencing?

- referencing is a standardized way of acknowledging the sources of information and ideas that you have used in your document.
- list of ALL the references used in the text must be written
- reference format varies widely:
 - Harvard format (the name and year system) is the most widely used
 - Alphabet-Number system is a modification of name and year system
 - In Citation order system

Reference list

- any papers not cited in the text should not be included
- reference lists allow readers to investigate the subject in greater depth

Paper organization

References (continued)

In-text citations

In name and year system:

- citation in the text is followed by the author's last name and year of publication between parentheses
 - if they were two authors then both last names are written
 - if more than two then the only first author's name is written followed by the abbreviation *et al*
- if a single statement requires more than one citation then the references are arranged chronologically from oldest to more recent, separated by semicolons
 - if more than one reference share the same year then they are arranged alphabetically within the year

In alphabet-number system:

- citation by number from an alphabetically arranged numbered reference list

In Citation order system:

- the references are numbered in the order they are mentioned in the text

Paper organization

References (continued)

Reference list

In name and year system:

- the reference list is arranged alphabetically by author
 - if an item has no author, it is cited by title, and included in the alphabetical list using the first significant word of the title
- if more than one item has the same author, list the items chronologically, starting with the earliest publication
- each reference appears on a new line
- there is no indentation of the references
- there is no numbering of the references

In alphabet-number system:

- it the same as above in addition each reference is given a number

In Citation order system:

- the reference list is arranged by the number given to the citation by the order that it were mentioned in the text

Paper organization

Figures

- **Do before writing**
 - Redraw, redraw, prune clutter
 - Least non-data-ink
 - Max 4 lines, all solid
 - No caption
- **Reduce size to 1 column in journal**
 - record as TIF (increased clarity)
- **Axes**
 - Minimize tick marks
 - Don't number each tick
- **Lettering**
 - Uniform, lower case
 - Minimize, avoid bold
- **Legend**
 - Gives message

Paper organization

Tables

- Do before writing
- Single unit, understood without text
- Prune, prune: columns, lines
- Exceed 1 sheet: redraw
- Avoid narrow/broad; rotate all 90°
- No added vertical/horizontal lines
- If small: move data to text

Tips for writing

Of writing

- at assigned time: write (not read)
- don't wait for the muses
- a craft, not an art: practice
- ideas come *while* writing
- read good writers

Momentum for writing

- fix a schedule - Monitor progress
- one page a week - torture
- skip trouble spots
- writer's block – unacceptable

Concentration

- need stretch of several hours
- when time is short: prepare, revise
- avoid distractions: phone, beeper
- location
 - very boring area
 - nothing to distract



First draft!!

- write as quickly as possible
- as if thinking out loud
- get everything down
- ignore spelling, grammar, style
- skip troublesome words
 - only you need to understand the first draft
- correct and rewrite only when the whole text is on paper
- do not split the manuscript among the co-authors

Good writing

includes:

- content, accuracy
- clarity; **means:**
 - clear
 - exact; **avoid:**
 - *ambiguity, inconsistency*
 - *wooly words*
 - concise
 - least words
 - short words
 - one word vs many
- precision
- logic
- Style
 - clear order of presentation
 - reads comfortably

Bad writing

- words don't do justice to the basic ideas
- If multiple mistakes in spelling and syntax occurred, reviewer suspects similar sloppiness in the lab

Use and misuse of English

- Tense
 - Previously published work: present tense
 - Your own work: past tense
- Voice
 - Active more precise and less wordy than passive
 - Name the worker, even with “I” or “we”
- Singulars and plurals
- Punctuation
- Hyphens
- Pile-ups of nouns or phrases
- Numbers

Polishing

- Reshape, refine, tighten up
- Juggle words, change sentences around
- Strengthen transition between sentences
- Check narrative flow
- After several drafts ask for a second opinion
- All first drafts have too many words
- Successive drafts: prune vigorously
- Strip every sentence
- Look for excessive adverbs, adjectives
- Writing improves in proportion to deletion of unnecessary words

Abbreviations & acronyms

- liked by authors, hated by readers
- Reading should not require a glossary
- Unwieldy word occurring > 10 times

Sentences

- Only one idea in a sentence
- Keep short: <20 words, but vary length
- Long sentences: greater risk of grammatical error

Paragraph

- Subheading over each one in early drafts
- Not too long (<125 words)
- Long paragraph: bad

Narrative

- Tell the story - reader follows it from start to end
- Writing is sequential - logic is the glue
- Smooth transitions
- Every step is inevitable

Re-writing

- Secret of writing is rewriting
- Secret of rewriting is re-thinking

- Decided as early as possible
- Should include persons who:
 - Can defend the intellectual content, including data and conclusions
 - Must be willing to concede publicly any errors

Criteria

- All the following criteria should be met:
 - Generate at least part of the intellectual content (conception or design, data analysis and interpretation)
 - Drafting, reviewing or revising critically for important intellectual content
 - Final approval of the version to be published

Order

- Some journals use the alphabetical order
- Most of them assume an order based on each author's importance to the study
 - The first author is primarily responsible for collecting and analyzing data, and writing
 - The last one, an established investigator, assumes the overall responsibility for the study
 - The middle authors are listed according to their order of importance to the study

Responsibilities

- The authors must comply with the following rules when submitting the manuscript for publication:
 - The manuscript is not under consideration elsewhere and the research will not be submitted elsewhere until a final decision has been made by the journal
 - The manuscript is a trustful, original work without fabrication, fraud or plagiarism
 - The authors have made an important scientific contribution and are familiar with the primary data
 - The authors have read the manuscript and take responsibility for its content, and understand that if the paper, or part of it, is found to be faulty or fraudulent, they share responsibility

Conflict of interest

- **All funding sources supporting the work and all institutional or corporate affiliations of the authors must be acknowledged**
- **The authors must certify that they have no commercial association that might pose a conflict of interest in connection with the submitted paper**