



Review

Anatomy and physiology of a scientific paper

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ABSTRACT

Writing and publishing a scientific paper in academic journals is a highly competitive, time-consuming stepwise process. The road to scientific writing and publication is rarely straightforward. Scientific writing has uniform format, which is perplexing for the novice science writers due to its inflexible anatomy (structure) and physiology (functions). Many obstacles are allied with the scientific writing path which can be minimized by applying some simple guidelines and practices. The scientific papers have an almost similar format but, original articles are divided into distinct sections and each segment contains a specific type of information. The basic anatomy of scientific papers is mainly comprised of the structure of the various components of a scientific paper, including title, abstract, introduction, methods, results, discussion, conclusion, acknowledgments and references. However, the physiology of a scientific paper is difficult to understand. Early career researchers and trainees may be less familiar with the various components of scientific papers. In this study, we applied an observational approach to describe the essential steps to facilitate the readers and writers to understand the basic characteristics, anatomy and physiology of writing the various sections of a scientific paper for an academic science journal.

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Many young physicians and researchers are interested in a career as an academic scientist and want to be a writer, but they must understand that scientific writing is a challenge and a life of science is also a life of writing (McDonnell, 2017). Writing research papers mainly is centered on the structure (Anatomy) and functional descriptions of the various sections (Physiology). The standard paper structure, including introduction, methods, results, discussion, conclusions is not only enough to keep track, but even with those sections, there is still enough freedom to get stuck in writing cul-de-sacs (McDonnell, 2017).

Writing and publishing a research paper is a common dilemma faced by most of the researchers (Bajwa and Sawhney, 2016). Scientific writing is a red-hot issue among the medical community due to its increasing academic and professional demands. A well written scientific manuscript is the daydream of authors, reviewers, editors and readers. The ability of framing an appropriate manuscript can be attained by adopting certain basic rules and techniques besides knowledge and skills. Best patient care is based on the preeminent available scientific evidence. Writing and publishing a scientific paper is a prerequisite for science and is an indicator of the merits of a scientist. Scientific paper writing skill is usually adopted with learning by doing and formal training (Auvinen, 2015). The purpose of this article is to highlight all the desirable anatomical and physiological features which would be kept in consideration while preparing and writing a scientific manuscript. Before discussing the various contents of the anatomy and physiology of a scientific paper, it is essential to know the prerequisites of a scientific paper and why researchers publish.

1. Prerequisites of scientific paper

Before boarding on the task of writing, it is essential to carefully consider the certain prerequisites that make the manuscript better (Kotz and Cals, 2013). A well-designed study is easier to write, before being convinced of the merit of an idea for research objectives, vigorously review the available literature to ensure the originality and identify the lacunae in the current knowledge on the subject. In an original article, the contents of the manuscript revolves around the data, hence, it is imperative to know the data

and findings thoroughly. The authorship should be settled as early as possible (Menezes et al., 2006; Marco and Schmidt, 2004). It is also essential to select the appropriate journal where the manuscript has a reasonable chance, depending on the scope of the journal, originality of the idea, quality of evidence and the importance of findings (Sengupta et al., 2014). Choosing the scientific journal for the prospective manuscript is a difficult decision, however, select the journal before starting to write the manuscript. Although, this choice is influenced by many factors, matching the journal's readership, journal's visibility, indexing, frequency of publication, acceptance rate and publication expenses involved (Bavdekar and Save, 2015). The "instructions to authors" section usually provides guidelines that differ from one journal to another. It is also essential that authors adhere to the general guidelines of a journal before putting a pen on a paper.

2. Why researchers publish

Writing and publishing a scientific paper in a peer reviewed academic journals are an imperative ingredient of research laterally with a professional career enhancing advantages and significant amount of personal satisfaction (Meo and Al-Saadi, 2007). Scientific publications are essential to share the ideas globally, enhance academic career, represents an opportunity to communicate their experience and provide a platform for a personal contribution to the knowledge of the science. The dissemination of ideas in the scientific community is a landmark for progress (Picardi, 2016). Scientific writing brings the science and scientists closer to the clinicians and bring benefit to the people (Normando, 2016).

Scientific publications are the golden eggs of an academic career, disseminate knowledge, boost the research profile and career progression. It encourages the discussion within the professional community and develop the high academic foundation. Considering the significance of why researchers publish, we established a pyramid called "SULTAN'S" pyramid (Fig. 1). In this pyramid, we highlight that researchers publish their research findings for their study requirements, hiring, promotions, grants, long-term sustainability, getting top rank positions, advancement in policies and name and fame among the science community (Fig. 1).

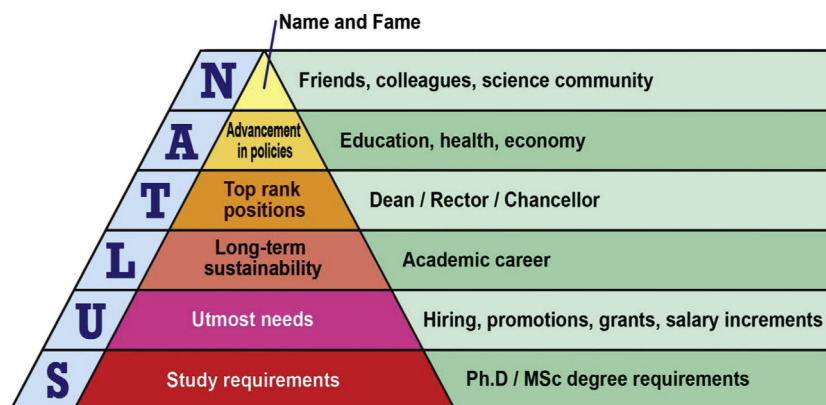


Fig. 1. SULTAN'S pyramid: Why researchers publish.

3. Title of the scientific paper

The title of the scientific paper is an incredibly important component of an article, as this is the first part of the article that an editor, reviewer and reader reads to understand the contents of the scientific paper. Title must be easy to understand and catalogue and has a good taste to fascinate the readers (Meo and Al-Saadi, 2007) (Fig. 2). The title should be concise, specific and convey the main idea with maximum information available on a subject (Grant, 2013).

Title must contain the primary key words describing the work presented and reflect the entire core contents of the manuscript. A good title is like an honest advertisement, fascinating the readers of the manuscript while a poor title is like a quarantine sign the readers read and then hurry away (Meo and Al-Saadi, 2007). Title must be simple, easy to understand, not so technical that only the authorities understand. The title should be short, unambiguous, without abbreviations and contain an adequate description of the entire work without any biased picture (Meo and Al-Saadi, 2007) (Fig. 2).

4. Abstract of the scientific paper

The abstract is the most important part of the manuscript, beside the title readers frequently read the abstract (Bavdekar and Gogtay, 2015). Abstract play multiple functions in the dissemination of intellectual knowledge. A brief and meaningful abstract serves as a resume for the manuscript (Goodman et al., 2016). The abstract of the scientific paper is the first part of the paper that a potential editor and reviewer appraise during the submission of the manuscript and readers appreciate when they search through electronic databases. The attractive abstract sets the tone for the entire paper and develops an interest in readers to peruse the contents of the paper. It is therefore the responsibility of the author to ensure that the abstract is appropriately representing the whole paper.

The abstract should be written according to the guidelines of the journal and preferable to restrict the word limit approximately 150–250 (Gambescia, 2013). No reference should be cited in the abstract section of the manuscript. The abstract summarizes the main information from all the sections of the manuscript using structured summary of the background, methods, results and conclusions. In the abstract section the author should answer the fundamental questions [i] Why did we start. [ii] What did we do. [iii] What did we find. [iv] What does it mean. These form the basis of

introduction, methods, results and conclusions (Ogrinc et al., 2016). The abstract facilitates the readers to select whether they want to read the entire paper or move onward. Therefore, provide enough principal information to make the abstract valuable to reference the work. Although abstract is the first part of the paper, it must be written last since it will summarize the whole paper. For composing the abstract, take the main sentences from each section and put them in order which summarizes the paper. Once you have the complete abstract, make sure that the information in the abstract completely agrees with what is written in the paper and also confirm that the information appearing in the abstract actually appears in the body of the paper. The abstract must contain general qualities as discussed in Table 1.

5. Introduction of the scientific paper

The introduction part of the scientific paper is an essential to tell the readers why the author (s) conducted the study. It is an essential to discuss the relevant primary research literature and summarize the current understanding of the problems which are being investigated. State the purpose of the work in the form of a hypothesis, questions, problems investigated and briefly explain the rationale and approach. The introduction section must answer the questions [i] What was being studied? [ii] What was the important question? [iii] What did we know about it before? [iv] and how does this study advance knowledge? Identify the key topics that the study deals with and introduce them within 4–5 paragraphs. In the first paragraph, describe the magnitude of the problem followed by a brief description of current knowledge and gaps that exist in the literature (Cals and Kotz, 2013).

The anatomy of the introduction section can be believed as an inverted triangle and narrowed down as a funnel shaped approach from a general overview of the subject to the specific question the study addresses. The broadest part at the top represent the most general information and focus down to specific problems. Shape the information to present the wide-ranging aspects of the subject early in the introduction, then narrow toward the more specific information that provides context, finally arriving at the statement of purpose and rationale.

The physiology of the introduction section of the manuscript is to start by clearly identifying the subject area of interest and in the first few sentences focused directly on the topic at the appropriate level. The primary subject matter should be discussed quickly without losing focus or discussing information that is too general. Moreover, state the purpose and or hypothesis that were

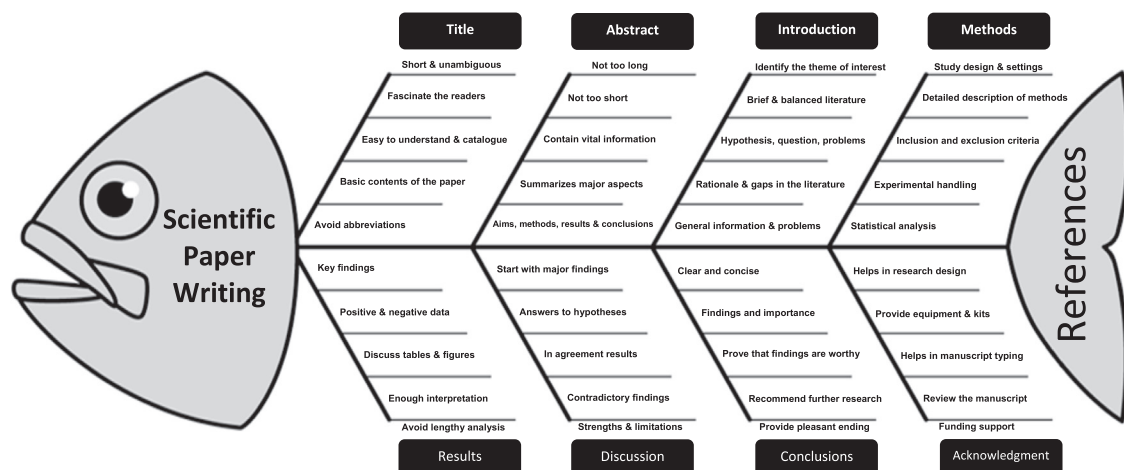


Fig. 2. MEO'S Fish Bone Model: Basic components of a scientific paper.

Table 1
Characteristics of various components of a research article.

<p>Title</p> <ul style="list-style-type: none"> ■ Short and unambiguous ■ Good taste to fascinate the readers ■ Easy to understand and catalogue ■ Contains key words describing the work ■ Describes the entire contents of the paper ■ Adequate description of the entire work ■ Avoid abbreviations and passive voice ■ Should not present a biased picture <p>Introduction</p> <ul style="list-style-type: none"> ■ Start by identifying the subject area of interest ■ Develop the settings by brief, balanced and relevant literature ■ Summarize the existing understanding of the problems ■ Discuss the study in the form of a hypothesis, question or problems ■ Briefly explain the rationale and gaps in the literature ■ Top of the introduction; represent general information ■ Bottom of the introduction; focus on the specific problems, purpose and rationale ■ Cite from the good research journals with original work rather than depending on reference books <p>Results</p> <ul style="list-style-type: none"> ■ Provide key findings in a logical progression ■ Report both positive and negative results ■ Organize results around the tables and figures ■ Provide nature of differences, relationship and magnitude of the findings ■ Provide enough interpretation ■ Provide appropriate measurement units ■ Use the word “significant” and “Non significant” accordingly ■ Avoid lengthy analysis and duplication of information <p>Conclusions</p> <ul style="list-style-type: none"> ■ State conclusions clearly and concisely ■ Start with clear statement of principal findings ■ Summarize the findings and generalize their importance ■ Prove that findings are worthy ■ Develop accuracy and originality in conclusion ■ Discuss ambiguous data and recommend further research ■ Conclude that testing supports or disproves the hypothesis ■ Provide pleasant ending with reader's utmost satisfaction 	<p>Abstract</p> <ul style="list-style-type: none"> ■ Not too long ■ Not too short ■ Contain about 200–250 words ■ Contain important information ■ Summarizes major aspects of the paper ■ Briefly state purpose, methods, results and conclusions ■ Written last since it summarize the entire paper <p>Methods</p> <ul style="list-style-type: none"> ■ Discuss study design, settings and how study was carried out ■ Biological features of control, exposed or treatment groups and variables measured ■ Age, height, weight, gender, ethnicity, educational and socioeconomically status ■ Study protocol, inclusion and exclusion criteria ■ Sample size and grouping, data collection and replication ■ Pre-experiment, experimental handling, measurements and procedures detail ■ Summarize data in Means, percent, *SD, **SEM, 95% CI, etc. ■ Statistical software used, data computed, analyzed and probability developed <p>Discussion</p> <ul style="list-style-type: none"> ■ Start discussion about your major findings ■ Provide answers to testable hypotheses relevance to existing knowledge ■ Discuss results with the findings of other researchers ■ Reference the findings of others in order to support your interpretations ■ Discuss contradictory findings with an alternative explanation ■ Never discuss prior work without reference ■ Point out where further gaps in knowledge could usefully be filled ■ Discuss study strengths and limitations <p>Acknowledgments to</p> <ul style="list-style-type: none"> ■ Who provide helps in designing and carrying out the research work ■ Who provide equipment, materials or reagents ■ Who provide assistance in your study ■ Who provide helps in manuscript typing ■ Who revised the manuscript ■ Who provide funding support ■ Support from department or institution, etc.
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investigated and place the statement of purpose at the end of the introduction section.

6. Methods section of the scientific paper

The methods section is usually the most important section in the scientific paper. This section should always be very clear with statistical and a power analysis (Wang et al., 2017) (Fig. 2). Preferably, the method section should be in detail to allow the other researcher to replicate the work. Start the method with explaining the overall strategy of the methods; discuss a series of methodology events in detail. Method contain detailed information to facilitate the reader to understand what was done, where was it done, and how was it done. The information should ideally be available in the methods section of a scientific paper about the study design, settings, biological features of control, exposed or treatment groups and variables measured. It is also essential to discuss the age, height, weight, gender, ethnicity, educational and socioeconomic status if the study is based on the human model. Moreover, provide information about study protocol, inclusion and exclusion criteria, sample size and grouping, data collection and replication, pre-experiment, experimental handling, measurements and procedures detail, and how the findings were summarized in means, percent, SD, SEM, 95%, etc. In addition, it is necessary to discuss the statistical software used, data computed, analyzed and probability developed (Fig. 2).

7. Result section of the scientific paper

The results section is the highly essential part of the scientific paper and nothing should compromise its range and quality. The readers learn about the outcomes of the study. The results section should therefore contain much detail about the findings. In a good scientific paper, it is essential to provide key findings in a logical progression, report both positive and negative results, organize the results around tables and figures, provide nature of differences, relationship and magnitude of the findings with enough interpretation. Provide appropriate measurement units, use the word “significant” and “non-significant” accordingly and avoid lengthy analysis and duplication of information in the result section. All figures, tables, graphs, charts, photographs must be readable and of good quality. Provide a brief descriptive title to each table and figure with number to figures and tables such as 1, 2, 3, 4 and provide the main points of the figures and tables in the text.

8. Discussion section of the scientific paper

The discussion section of the scientific paper is often considered the most important part of a research paper since it provides effective solutions to the issues based on the logical synthesis of the findings and formulates more profound understanding of the research problem. The main objective of the discussion section of the scientific paper is to describe the meaning of the results to the reader and interpret the finding. The discussion should start

with major findings of the study (Vitse and Poland, 2017) provides answers to testable hypotheses relevant to existing knowledge. Discuss the results with the findings of others and refer to the findings in order to support your interpretations. Moreover, it is essential to discuss contradictory findings with an alternative explanation and never discuss prior work without reference. Point out where further gaps in knowledge could usefully be filled and discuss study strengths and limitations.

The anatomy of the discussion should be as an inverted pyramid. Organize the discussion from the general to the specific and link the findings to the literature. There should be 6–8 paragraphs, the first paragraph stating major findings, why the findings are essential, and provide answers to testable hypotheses relevant to existing knowledge. The middle paragraphs consist of 4–6 paragraphs relating the findings to those of similar studies, supporting your findings, which strengthens the importance of your study results.

Discuss the results with the findings of other researchers, analyze any unexpected findings and briefly interpret why it appeared. Provide alternative explanations of the findings in contradictory literature and provide reliable reasons with standard references. Refer the readers to the figures or tables to enhance the interpretation of the data. The last 1–2 paragraphs point out where further gaps in knowledge could usefully be filled instead of “further research is needed”. Before concluding the discussion, identify study’s potential strengths and limitations (Hess, 2004).

9. Conclusion section of the scientific paper

The conclusion is the most important component of the scientific paper that readers always want to remember. The first sentence of the conclusion section should be very clear with principal findings that should be considered the take-home message. The conclusion section is always at the end of the discussion and requires a separate heading. In conclusion, provide clear scientific justification for the work and indicate uses and extensions if appropriate. The conclusion section also provides suggestions for future experiments. Practice change if appropriate and provide pleasant ending with reader’s utmost satisfaction.

10. Acknowledgment section of the scientific paper

Conducting a research and writing of scientific paper needs support from institutions, friends and fellows. It is essential to acknowledge those who help you in this journey. Receiving any assistance in intellectual thoughts, designing, carrying out the study, received materials, typing and reviewing the manuscript, must acknowledge their assistance and their services. Funding agencies require acknowledgments along with the specific grant number that supported the work. Acknowledgment section is optional, always brief and never flowery. The best place of the acknowledgment section is between the discussion and the bibliography.

11. Reference of the scientific paper

It is essential to appropriately cite the references in text and bibliography section of the research papers in order to acknowledge the sources and provide credit and validity to the arguments. Support the manuscript with novel references from leading science journals to enhance the validity and reliability of the work. In the text, cite all the scientific publications on which work is based, do not over-inflate the writing with too many references. In an original article 25–30 references are sufficient to provide the best scientific coverage to the manuscript. Avoid excessive self-

citations, citations of publications from the same region, unpublished observations, publications which are not peer reviewed and grey literature. There are a number of different tools to manage references, but few are very popular and easy to manage such as EndNote Web, Mendeley, Zotero. Most of the science journals mainly follow the following format: Author (s); name of the journal, year of publication, volume number, page numbers. If the references are from books without editors state author (s) chapter title, book title, edition number, publisher, place of publication, year, volume number and pagination, while for books with editors: author (s), chapter title, book title, edition number, editor (s), edition, publisher, place of publication, year, volume number and pagination.

12. Conclusion

To understand the anatomy and physiology of scientific paper novice writers must understand the basic characteristics, design and functions of writing the various sections of a scientific paper. They must have a mentor and work on writing as a team, the authors can gain self-efficacy, manuscripts could be improved, thoughts and writings can be clarified. Scientific paper writing skills would be improved during an individual’s training, facilitated by short and intensive courses that would cover the basic facts about scientific paper writing. Such courses would be ideally delivered by experienced faculty, science writers, especially the editors of the academic journals.

Conflict of interest

The authors declare that there are no conflicts of interest.

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