Article

Scientific Writing: Strategies and Tools for Students and Advisors

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Abstract

Scientific writing is a demanding task and many students need more time than expected to finish their research articles. To speed up the process, we highlight some tools, strategies as well as writing guides. We recommend starting early in the research process with writing and to prepare research articles, not after but in parallel to the lab or field work. We suggest considering scientific writing as a team enterprise, which needs proper organization and regular feedback. In addition, it is helpful to select potential target journals early and to consider not only scope and reputation, but also decision times and rejection rates. Before submission, instructions to authors and writing guides should be considered, and drafts should be extensively revised. Later in the process editor's and reviewer's comments should be followed. Our tips and tools help students and advisors to structure the writing and publishing process, thereby stimulating them to develop their own strategies to success. © 2014 by The International Union of Biochemistry and Molecular Biology, 42(5):405–413, 2014.

Introduction

Scientific writing is a critical competence for careers in science. Graduate students and researchers have to write to communicate their findings and to develop their profiles as renowned scientists [1]. Science is highly competitive and success in science is often measured by the number of publications and citations. Researchers and students who are able to communicate well are not only successful in gaining recognition for themselves but also for their institute and university. In the long run, publications pave the path to job positions, collaborations, and better funding. Thus, it is crucial for students and researchers to achieve proficiency in scientific writing.

Students and researchers are usually well trained and motivated in designing, performing experiments, and analyzing data. However, many of them received no formal training in scientific writing [2] and struggle with various challenges during the writing process (see ref. [3] for a description of cognitive and socio-cultural demands of writing). As a consequence, many relevant findings do not reach their target audiences. Students and researchers often make the mistake of understanding the preparation of scientific articles as a separate phase in the research process to be done after completing experiments [4, 5]. In addition, many students and advisors are not aware of available tools and guides.

Through this essay, we highlight a few important tips for efficient scientific writing which could also be considered for theses, proposals, review articles, and other text types. We also suggest various writing guides and software tools that make scientific writing less demanding and more exciting.

Early Beginning is Beneficial

Scientific writing is a learning process, and one masters this skill through experience. Therefore, we recommend starting early. The first step in this process is extensive and attentive reading in order to get an overview of the published literature, also to acknowledge the structure and style of research articles. It is here during this stage where many students do not invest sufficient time to read enough so as to gain a sound grasp over their literature. Once, the student has established

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TABLE 1	Software-tools for different stages of the writing process

Stages of Writing Process	Tools	Links	Rationale and Recommended Tools
PREPARING			
a) Note taking	Evernote*	http://evernote.com/evernote	Writing is easier with personal ideas and information from the literature at hand. Evernote and OneNote both support various formats (e.g. texts, photos) and devices (e.g. notebook, smartphone).
	LexiCan	http://www.lexican.net	
	OneNote	http://office.microsoft.com/de-de/onenote	
b) Structuring thoughts	CmapTools*	http://cmap.ihmc.us	Organize your thoughts and your information before you begin to write. If you like mind maps try Freeplane. If you like flowcharts try draw.io. If you like lists try WorkFlowy.
	draw.io*	https://www.draw.io	
	Freeplane*	http://freeplanes.sourceforge.net	
	MindMeister	http://www.mindmeister.com	
	The Brain	http://www.thebrain.com	
	WorkFlowy*	http://workflowy.com	
c) Reference management	Bookends	http://www.sonnysoftware.com	Reference management software helps organizing article PDFs, inserting citations and preparing bibliographies. EndNote is rich in features and time-tested. Mendeley offers innovative collaboration functions and is free.
	Citavi*	http://www.citavi.com	
	CiteULike*	http://www.citeulike.org	
	Colwiz*	http://www.colwiz.com	
	Docear*	http://www.docear.org	
	EndNote	http://www.endnote.com	
	Mendeley*	http://www.mendeley.com	
	Papers	http://mekentosj.com/papers	
	Quiqqa*	http://www.qiqqa.com	
	RefWorks	http://www.refworks.com	
	Sente*	http://www.thirdstreetsoftware.com/site/SenteForMac.html	

TABLE 1 *(Continued)*

Stages of Writing Process	Tools	Links	Rationale and Recommended Tools
	Zotero*	http://www.zotero.org	
d) Collaboration	Etherpad*	http://etherpad.org	These tools aid in writing collaboratively and in sharing manuscripts. Public instances of Etherpad allow collaborative writing and editing. Wuala offers cloud storage with advanced encryption.
	Dropbox*	http://www.dropbox.com	
	Google Drive*	https://drive.google.com	
	Mind42*	http://www.mind42.com	
	Wuala*	http://www.wuala.com	
DRAFTING e) Avoiding distractions	Dark Room*	http://jjafuller.com/dark-room	These tools help to focus on writing. Which one to choose is a matter of taste (and of operation system).
	FocusWriter*	http://gottcode.org/focuswriter	
	Ommwriter*	http://www.ommwriter.com	
	WriteRoom	http://www.hogbaysoftware.com/products/writeroom	
	ZenWriter	http://www.beenokle.com/zenwriter.html	
f) Achieving productivity	focus booster*	http://www.focusboosterapp.com	For the drafting stage, some time pressure is beneficial for most of us. Have a look at Write or Die to find out what we mean.
	Write or Die	http://writeordie.com	
g) Speech recognition	Dragon Naturally Speaking	http://www.nuance.com/dragon/index.htm	There are different reasons to use speech recognition software: to save time, to do it on the go, for a change. Dragon NaturallySpeaking is known for its recognition accuracy.
	Mac (OS X Mountain Lion)	http://support.apple.com/kb/PH11481	
	Windows (7 and 8)	http://windows.microsoft.com/is-is/windows-8/using-speech-recognition	

TABLE 1	(Continued)		
Stages of Writing Process	**Tools**	**Links**	**Rationale and Recommended Tools**
REVISING			
h) Grammar, punctuation and spell checking	Grammarly	http://www.grammarly.com	These tools help to avoid mistakes and to improve writing skills. All three products are effective but not for free.
	WhiteSmoke	http://www.whitesmoke.com	
	Writer's	http://www.emo.com/index.html	
	Workbench		
i) Readability	Readability Test Tool*	http://www.read-able.com	Based on sentence and word length, the readability test tool calculates several indices.
	Word (Microsoft Office)	http://office.microsoft.com/ en-001/word-help/test-your-document-s-readability-HP010354286.aspx	
j) Layout	InDesign	http://www.adobe.com/ products/indesign.html	Some publishers ask authors to design the layout of their research articles. In these cases, and for theses and books, layout software is helpful. InDesign is a high-end and high-priced tool. A free alternative is Scribus.
	Latex*	http://www.latex-project.org	
	PagePlus	http://www.serif.com/pageplus/	
	Publisher (Microsoft Office)	http://office.microsoft.com/ en-001/publisher/	
	Scribus*	http://www.scribus.net	

These tools facilitate the process of writing research articles and help to improve text quality.

*freeware (software free of charge) or freemium (basic services for free, premium services with costs).

his/her knowledge over the literature, the second step is checking the usefulness of available software tools and writing guides. Appropriate tools and guides for students and researchers in the life sciences are listed in Tables 1 and 2. The third step is to check the services of local writing centers. Many universities offer services to help students to develop their writing skills. We recommend that students preparing research articles, dissertation theses, or other texts make use of the university writing centers. The writing centers not only serve as sources for improving writing skills but also provide students with templates in order to facilitate the writing process.

Then it is time to plan one's own research article. Outlining and drafting one's first research article as early as possible is crucial. A detailed outline facilitates the writing process [6] and the outline of a research article holds the key toward its success. Structural templates facilitate this outlining process (see Fig. 1). Although an outline and a draft are far from a final version and will not reflect the full amount of work to be performed, it surely provides a student with aerial views of the research project and also signifies the most important experiments and critical areas that need more consideration.

Additionally, by writing piece by piece provides new researchers with the perception of what to do and when,

TABLE 2	Recommended writing guides for students in the life sciences

Guide	Strength
Albert, T. (2009) Winning the Publications Game – How to Write a Scientific Paper Without Neglecting Your Patients, 3rd ed., Radcliffe Publishing, Oxford, New York, 114 p.	• Stepwise approach from idea to submission • Unconventional, encouraging, subversive advice • Easy to read • Concise
Alley, M. (1996) The Craft of Scientific Writing, 3rd ed., Springer Science + Business Media, New York, 282 p.*	• Classical textbook, archetype for many other writing guides • Well-written, you can read it in a few sittings • Clear and concise
Cargill, M., O'Connor, P. (2013) Writing Scientific Research Articles – Strategy and Steps, 2nd ed., Wiley-Blackwell, Chichester, 223 p.	• Clearly structured (the author's teaching experience becomes obvious) • Easily-accessible • Instructive exercises and examples
Council of Science Editors, Style Manual Commitee (2006) Scientific Style and Format - The CSE Manual for Authors, Editors, and Publishers, 7th ed., Council of Science Editors, Reston (VA), 658 p.	• Extensive and authorative desk reference • Style conventions are presented (e.g. abbreviations, numbers, chemical notations, species names)
Davis, M., Davis, K., Dunagan, M. (2012) Scientific Papers and Presentations – Effective Scientific Communication, 3rd ed., Elsevier, London, 368 p.	• Focus on communication skills for scientists • Besides the preparation of research articles various other topics are covered (e.g. posters, proposals, theses, oral presentations, communication with nonscientists)
Day, R.A., Gastel, B. (2011) How to Write and Publish a Scientific Paper, 7th ed., ABC-CLIO, LLC, Santa Barbara (CA), 300 p.	• Extensive coverage of topics related to scientific writing and publishing • Engaging style • Practical advice without inappropriate simplifications
Fraser, J. (2008) How to Publish in Biomedicine – 500 Tips for Success, 2nd ed., Radcliffe Publishing, Oxford, New York, 191 p.	• Easily-accessible: no reading of long blocks of text needed • Extensive coverage of topics related to scientific writing and publishing • Practical advice
Gladon, R.J., Graves, W.R., Kelly, J.M. (2011) Getting Published in the Life Sciences, Wiley-Blackwell, Hoboken, NJ, 356 p.	• Convincing approach to writing with take-home messages developed first • Comprehensive coverage of topics related to scientific writing and publishing
Glasman-Deal, H. (2010) Science Research Writing for Non-native Speakers of English, Imperial College Press, London, 257 p.*	• Structural templates for article sections are provided • Grammar issues well explained • Useful vocabulary lists
Greene, L. (2010) Writing in the Life Sciences – a Critical Thinking Approach, Oxford University Press, New York, 512 p.	• Detailed description of involved steps • Stimulating connections between citical thinking and clear writing • Many examples
Gustavii, B. (2008) How to Write and Illustrate a Scientific Paper, 2nd ed., Cambridge University Press, Cambridge, 168 p.	• Straightforward, friendly advice • Helpful tips how to present numbers, prepare tables and design graphs • Concise

TABLE 2 *(Continued)*

Guide	Strength
Hall, G.M., Ed. (2013) How to Write a Paper, 5th ed., BMJ Books, John Wiley & Sons, Chichester, 170 p.	• Perspectives of different experts presented • Topics included which are neglected in other writing guides (e.g. electronic submission, ethics of publishing, open access)
Katz, M.J. (2009) From Research to Manuscript – a Guide to Scientific Writing, 2nd ed., Springer Science + Business Media, 205 p.	• Convincing advice how to integrate writing in the research process • Helpful tips for the preparation of tables and figures
Lebrun, J.-L. (2011) Scientific Writing 2.0 – a Reader and Writer's Guide, 2nd ed., World Scientific Publishing, Singapore, 265 p.*	• Unconventional presentation of information • Enjoyable to read • Helpful focus on reader's needs
Matthews, J.R., Matthews, R.W. (2008) Successful Scientific Writing– a Step-by-Step Guide for the Biological and Medical Sciences, 3rd ed., Cambridge University Press, Cambridge, 240 p.	• Practical, well-founded advice • Information is easily accessible • Comprehensive coverage of topics related to scientific writing (e.g. literature search strategies, preparation of visuals)
Schimel, J. (2012) Writing Science – How to Write Papers that Get Cited and Proposals that get Funded, Oxford University Press, New York, 221 p.	• Stimulating, unconventional advice for advanced writers • Narrative structure of research articles well explained
Skern, T. (2009) Writing Scientific English – a Workbook, Facultas Universitäts verlag, Wien, 191 p.	• Straightforward advice for beginners • Language issues covered (helpful for non-native speakers of English) • Instructive exercises (it is a workbook)
Zeiger, M. (2000) Essentials of Writing Biomedical Research Papers, 2nd ed., McGraw-Hill, New York, 440 p.	• Extensive, clear, practical • The structure of research articles is well explained • Instructive examples and exercises

These books do not focus on the life sciences but address readers of the natural sciences. Nevertheless, these books are helpful for students in the life sciences.

thus helping them in avoiding unnecessary work. This makes the work more efficient, by better time management and planning. A helpful description of steps toward a research article is provided by ref. [7].

Writing is not a single step, pre-set rigid process; rather it is a step-by-step learning process with a learning curve that requires regular feedbacks and continuous evaluation of the written matter [3, 8]. Thus, one should aim to write and work in small increments [9]; analyze what one has done, what went well and what can be improved.

Working in Teams

Scientific research and scientific texts are collective outputs of a few people, a group or an institution. Thus a group has power, and writing articles as a group is beneficial as it leads to enhancement of both efficiency and output. Writing articles in groups not only adds a new perspective to aims, arguments, and conclusions but is also a smart strategy to obtain necessary feedback.

Seeking feedback is helpful for efficient scientific writing. Feedback helps to detect inconsistencies, inappropriate text structures, unclear messages, wordy text parts, and errors and will lead to improved text quality. In addition, feedback helps students to recognize their strengths and weaknesses. Students should seek their advisor's feedback frequently as they write. Regular feedback leads to suggestions and foster students' learning processes. Thus feedback is a critical element for the development of writing skills.

Professional team work in writing articles helps to reduce the workload for the first author. A productive team could be formulated with colleagues, supervisors, and co-others. The workload, as well as responsibilities and roles of involved people, should be specifically assigned, and this helps to keep the time schedule in check and meet deadlines. To facilitate collaboration and file sharing, user friendly internet tools are available (Table 1).
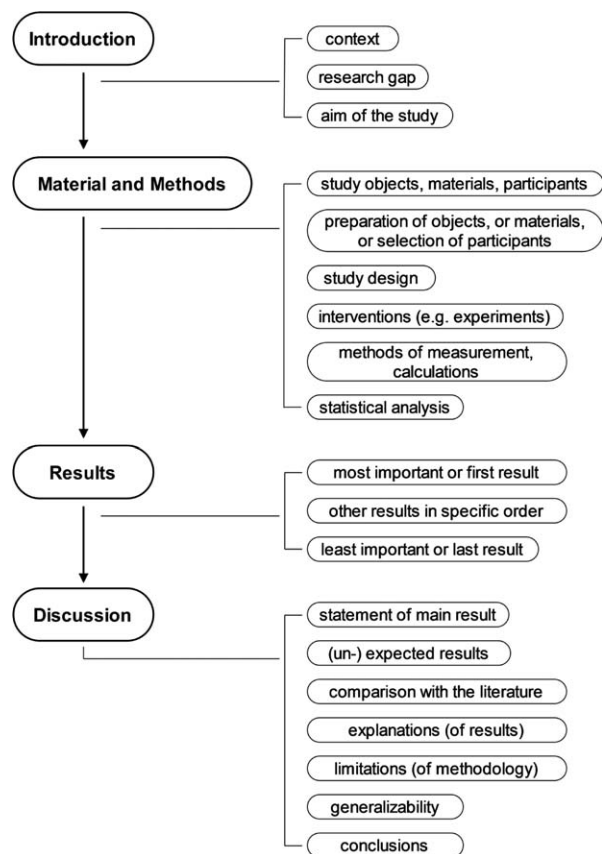
FIG 1 *Typical components of research articles in the life sciences (adapted from refs. [24] and [25]). Each component reflects one or several paragraphs.*

Having a leader in a writing team is recommended. A leader acts as a unifying force that helps to maintain stability and cohesion [10]. Furthermore, in the presence of a leader there is reduced frustration, repetition, redundancy and uncertainty among the team members [11]. Also, the selection of a leader avoids the situation where the most dominant person takes over unofficially in the group and preferentially considers his/her own views and thoughts [10].

However, writing in teams is not always a pleasant experience: It can lead to deadlocked discussions; waste of time, frustration (see e.g. ref. [12]), Advisors and students should not forget that teamwork in general is a demanding management issue. Therefore, people involved in writing teams should invest time and effort in the organization of processes [12], and should be aware of potential pitfalls and should be flexible enough to negotiate.

Selecting a Journal

We recommend choosing the target journal early in the writing process. Indeed, we suggest having the journal already selected while preparing the rough draft of the article [4]. This is beneficial because different journals follow different schools of thought, have different article types, and different stylistic and bibliographic requirements. Therefore, writing an article directed towards a specific journal not only helps to choose the appropriate content and style but also saves time and avoids unwanted modifications and deadlocks during the final preparation of the article.

According to Harnad *et al.* [13] about 24,000 peer-reviewed research journals exist worldwide. This means that there are enough publishing opportunities in almost every field of science. While selecting a target journal it is advised to carry out an analysis of aims and scope of the journal, to examine the type of articles that are being published with respect to their structure, methodology and research topic. Additionally, crucial aspects that need due consideration while selecting journals, especially by graduate students and new researchers, are decision times and acceptance rates. The "Decision time" for a journal is defined as the time between manuscript submission and the editor's decision. The information regarding decision time could be obtained in three ways [4]. (*a*) All journals print dates of submission and acceptance together with publications. (*b*) Some journals also provide decision times on their web pages. Lastly (*c*) one may also ask for the decision time of a journal by sending a polite email to the managing editor. Information regarding acceptance rates might be found on journal websites.

Another parameter that is often referred to by researchers while selecting a journal is the "impact factor" [14]. The impact factor (IF), devised by Eugene Garfield, reflects the average number of citations to articles published in the journal [15, 16]. The IF is used to compare the importance and standard of different journals in a particular discipline [14]. Journals with high IF are considered of high significance and often researchers are evaluated based on the IFs of the journals they have published in ref. [13]. Nonetheless, the IF is merely arithmetic, and IF should not be used as a parameter to evaluate the level and quality of scientific work performed by a researcher [17]. Furthermore, the IF has various shortcomings [17–19] and should not be considered as the sole criteria for assessing journal reputation. Other metrics that could be used for selecting target journals are Eigenfactor [19], Immediacy Index, Hirsch Index [20, 21], and SCImago Journal rank [19, 22]. Additional criteria to considered are, for instance, informal reputation of the journal, open access options, copyright regulations, publication costs, and peer review systems.

Nurturing the Manuscript

Once a student has finished writing a manuscript, thesis, or dissertation. There must be adequate time for internal reviewing among colleagues, for nurturing its content and

improving the style. During this phase, students are advised to strive for clarity in their manuscript. The best way to achieve clarity and continuity within the manuscript is by having clear and precise paragraphs. The beginning of the paragraph should state the main purpose or topic of the entire paragraph while the ending could be used as an introduction to the following paragraph. By doing this in practice, writers can establish a flow of information from one paragraph to the next. The second critical aspect that needs to be checked is accuracy. In order to strive for accuracy, students are advised to check their data, their line of reasoning and their references. Third, we recommend focusing on language issues such as grammar, spelling and punctuation. Grammar and spell-checking software (see Table 1) helps to avoid mistakes and various writing guides (see Table 2) provide practical tips for betterment of the manuscript.

In this stage, we recommend to ask for outside help. One may want to benefit from professional editing services. The costs of editing a manuscript usually ranges between US $100–$350, depending on the length of the text and the amount of work required. If the services of a writing centre are accessible, students should make use of their services in this stage. The revising step is often a neglected part; this is critical as this step leads to quality in scientific manuscripts. Hence, students are advised to make sure to have enough time for revision, use checklists, software tools, and writing guides. Once the authors have finished re-revising (improving) their manuscript, it is then ready to be submitted to the journal. After submission of the article, editors will acknowledge that they received the manuscript.

Responding to Decisions

Manuscripts are usually reviewed by two or more experts independently [23]. These experts (reviewers) write a review report and editors decide whether to reject or accept the manuscript. At first glance, the feedback of reviewers and editors may seem harsh and ask for substantial changes in the manuscript or the conductance of additional experiments. However, text feedback should never be intended to judge the abilities and skills of the authors. Reviewer's and editor's comments can be helpful in improving writing skills. Moreover, manuscripts will subsequently get better if the authors act as advised. Most editors and reviewers are trying to improve the paper, not to destroy it, with their suggestions. In case of acceptance with minor revisions, it is necessary to analyze carefully what the comments mean and to react swiftly to the given feedback by kindly acknowledging the criticism. It is helpful to provide a point by point response acknowledging reviewer's and editor's comments together with the modified manuscript. If authors do not agree with the critique, they should justify their decision. And finally: There is no reason to despair upon rejection. Authors can always try another journal.

Conclusion

Here, through this essay, we have highlighted ways to make scientific writing a creative, effective, and manageable process rather than a cumbersome one, as often felt by students. If students start early with writing, consider it as a team enterprise, learn from advice given to them by advisors, colleagues, editors, and reviewers, select journals carefully, and revise extensively, successful writing and publishing is possible. In addition, various software tools and writing guides are available which speed up the writing process and help to improve text quality. However, these tips and tools should not be seen as rules or mandatory regulations that students must follow for successful writing and publishing. Students are advised to opt for best possible individual strategies that suit their habits, attitudes, and interests.

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