

The Art of Scientific Writing and Ethical Use of Artificial Intelligence

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We share our consolidated views, long-term experiences, and best tips for effective scientific writing. After writing hundreds of manuscripts and thus having battled and succeeded in this “minefield”, and knowing the importance of guidance for successful science communication, particularly for beginners, we have tried to introduce readers to the art of scientific writing, *from A to Ω*. To help less experienced scientific writers to learn quickly and overcome some initial barriers, avoiding common mistakes that we ourselves have also made, we discuss the most important techniques we have used in trying to write clear, comprehensible, and concise manuscripts that are as attractive and impacting as possible. This guide therefore offers crucial tips and concepts - from the very first words, initial draft, and on to submission, “battles” with reviewers and finally to acceptance and publication. The ethical use of artificial intelligence tools, along with some best practice suggestions for their application, is also presented and discussed. In the end, readers should have a comprehensive picture to help them understand basic manuscript structures and major features, habits and tips that help ensure excellence in scientific writing.

Keywords: scientific writing, publication, article, structures, artificial intelligence (AI), ethics

1. Introduction

For Voltaire, “*writing is the painting of the voice*”. We agree wholeheartedly. Writing is indeed a hard and multifaceted art to master, full of nuances and styles, therefore demanding continuous learning by numerous trials and error, extreme persistence and dedication. No matter how experienced we are, we always make mistakes, learn from them, and then improve. Therefore, you may always face difficulties when writing, but most intensively and riskily when writing scientific manuscripts, which requires extreme attention to accuracy and therefore the very best possible selection of words and terms. Even when you are naturally gifted as a writer, scientific reports and their peculiarities, which are to reach distinguished levels of writing need much focus, dedication, discipline, and practice. In science, the quality of our work is judged

essentially by how we write (and talk); therefore, scientific writing is undoubtedly the most daunting and anxiety-provoking task of the academic experience.¹ A scientific career can be greatly boosted by a few outstanding manuscripts, or destroyed by a single disastrous article. Excellent data can also have their merits drastically diminished and remain unknown when reported in poorly written manuscripts, whereas modest but relevant data can make it into a top journal and be frequently cited if its relevance is properly highlighted in a well-written manuscript. When published in lower-quality journals but with the proper audience, well-written manuscripts with excellent data can end up being highly cited. It is therefore mostly *up to you* to shape your destiny in scientific writing!

But in general, despite its pivotal importance, students receive little if any classes in which they are taught appropriate scientific writing.² The art is hard to master, but the need and pressure for publishing,³⁻⁵ as illustrated by the well-known “*publish or perish*” culture, is tremendous and

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sometimes suffocating. This may either lead to increasing dedication or to depression, or scientific ostracism, as recently debated.⁶ But those brave enough to face the challenge and fight the “writing battle” to the end with enthusiasm, will finally master this art. And indeed, the personal satisfaction of being regarded as a prominent writer and by seeing your work properly and clearly shared within the scientific community is tremendous.⁷⁻⁹ To illustrate our point, we will paraphrase the Nobel laureate in Physics, J. J. Thomson, using what he wrote in 1905,¹⁰ one year before receiving the award:

“As we conquer *peak* [manuscript] after *peak* [manuscript], we see in front of us *regions* [future manuscripts] full of interest and beauty, but we do not see our goal [of perfect writing], we do not see the horizon; in the distance tower *higher peaks* [still better manuscripts], which will yield to those who *ascend* [write] them *still wider prospects* [even better manuscripts], and deepen the feeling, whose truth is emphasized by every advance in science, that ‘Great are the Works of the Lord’ and [greater and greater are the manuscripts from those who persist in the quest of writing excellence]”. (adapted from reference 11)

To publish is a *must* since science advances only when scientists properly disclose their results via publication. Publishing is therefore an essential and ethical aspect of the academic life and a measure of academic quality and career advancement. *Unpublished work is lost work!* Indeed, as G. M. Whitesides has emphasized:¹²

“If your research fails to generate papers, it might just as well not have been done. ‘Interesting and unpublished’ is equivalent to ‘non-existent’”.

As “money attracts money”, “high-quality manuscripts also attract funding to do more work and therefore produce more high-quality manuscripts”. To acquire skill in the art of scientific writing is therefore an essential strategy to attract sufficient research funding, making publishing a major and highly competitive aspect of the scientific life.¹³ Science is indeed a “*survival of the most writer*” endeavor.

But since we measure the quality of a scientist mostly by indexes that combine the quantity and quality of publications, and as we measure quality also by citations, and since citations in general directly correlate with the quality of data plus writing, and as competition for funding is increasing, the need to become skilled in scientific writing is proportionally increasing. We are aware that manuscripts can be cited for the wrong reasons, but we believe that

research outputs should be evaluated in a fair and balanced manner to avoid such biases. This is why many reputable scientific communities have embraced initiatives aimed at preventing the misuse of scientific indicators, such as impact factors. The San Francisco Declaration on Research Assessment (DORA) serves as a good example of such initiatives.

Obviously, “error-free” manuscripts are impossible for fallible humans to write, but *we must all keep trying*. We agree with the idea that “*perfection is the ideal, but an obstacle to getting things done*”.¹⁴ Sometimes, beginners keep postponing publication from unjustified fears of unintentionally reporting wrong conclusions. We do not intend to encourage poorly conducted, written, and analyzed work to be published, but this risk is also part of the scientific life and should never hinder us from publishing. A great attribute of science is its mechanism of purging such errors with more scientific data. *Science corrects itself!*

What must, above all, be avoided is scientific misconduct¹⁵⁻¹⁷ such as publishing unethically generated data (e.g., the paper mills¹⁸ problem) and plagiarism, by far the main problems with retracted manuscripts.¹⁹ Unintended mistakes just happen and are inevitable for all scientists, but misconduct is a conscious – *and therefore avoidable* – decision.

In summary, the major benefits of well-written manuscripts are:

- (i) *Easier for reviewers and readers to understand, therefore more likely to be accepted, appreciated and cited;*
- (ii) *Greater chance of becoming a reference manuscript with a significant impact on its field.*
- (iii) *Add positively to authors’ reputation, facilitating fund-raising, collaboration, invitations to conferences, therefore better networking, and overall scientific visibility.*
- (iv) *A well-written paper can make “waters abundantly flow from the rock of useful but not so exceptional data”.*
- (v) *Indeed, “in science we like any fish we fish, and the size of it depends on how well we sell it!”.*

2. General Tips to Excellence in Scientific Writing

For us, the top 5 general rules for best scientific writing are:

1. **Be a voracious reader of scientific manuscripts.** Indeed, “*the more you read scientific manuscripts (the*

good and the bad ones), the better writer of scientific manuscripts you become". Read as many manuscripts as possible, always attentive to their style and quality. "Test them all; hold fast to that which is good"!

2. **Be concise.** In scientific writing, "less is much more". Good data put in a short manuscript is much more likely to be accepted, read, and cited than a many pages-long one. See, for example, the near-one-page-long work by the Nobel prize winner on the structure of DNA,²⁰ or one of the shortest-ever 378 words-long announcement in *Nature* by Aston,²¹ of the discovery of isotopes (Ne), which won him the 1922 Nobel prize in chemistry. As La Rochefoucauld stated: "True eloquence consists in saying all that is necessary and nothing but what is necessary". Always remember that "the unit of well-written manuscripts is not pages, but quality of data and presentation offered in the fewest possible number of words". Another rule of thumb is this: *the longer you write a sentence, the more tired of reading it your editor, reviewer and reader will be!* For instance, replace:

"The reaction that has been performed between ammonia and carbon dioxide, at the temperature of 25 °C and a pressure of 2 atm, at the end, in a fast fashion after a period of time of only two hours, led to the formation of ammonium carbonate in the very high yield of 90%".

By:

"NH₃ rapidly reacts with CO₂ at 25 °C and 2 atm, forming, after 2 h, 90% of (NH₄)₂CO₃".

Never give, therefore, irrelevant details of common instrumentation or very common reagents/solvents, nor repeat information already provided. Avoid all redundant words or statements. After you finish writing, set the goal of reducing your manuscript by at least 30%, working at one sentence after the other. You can probably reduce it by half, or even more! Feel free to use this current manuscript as an exercise in which you apply the same rules.

Hunt for excessive adjectives and superlatives deleting, for instance, "very" from "very high yields". Replace actions described by the description of verbs, adjectives and adverbs by the actual verb, adjective or adverb being described, for example: replace "led to the formation of" by "formed", or "reduced the speed" by "slowed", or "contributed to promoting an increase in velocity" by "accelerated", or "in the case of mutations" by "for mutations", or "in a clear fashion" by "clearly", or "take

into consideration" by "consider". Your text will also sound more confident if you write affirmative sentences instead of negative ones; therefore, replace, for instance, "did not form" or "not difficult" by "failed to form" or "easy".

Also use verbs in the active voice – *they sound better and save space* – so replace "the setup is shown in Figure 10" by "Figure 10 shows the set up". And most important: never use widely used but useless scientific jargon such as: "It is interesting to note" or "last, but not least". Replace these empty phrases by "note that" and "lastly" or simply delete them! Several books may help you to improve your style and conciseness.^{22,23}

As a guide, remember that manuscripts normally range from 2k to 8k words²⁴ and that longer manuscripts with more authors and references tend to be more cited,²⁵ but the correlation is likely with quality/quantity of findings and interdisciplinarity, not words! The cost/benefit ratio of manuscript length is indeed "discouraging" since a study²⁵ showed that, on average, a 2 page-long manuscript receives fair enough citations (10 on average) which are just 2/3 lower than 22 page-long manuscripts (15 citations). That is, after 2 pages and 10 citations on average, you need ca. 3 additional pages to gain an additional citation! So, the rule is: the more relevant and interdisciplinary findings described in fewer words, the better!

3. **Be precise.** That is: "remove ambiguity as much as possible". Scientific reports should be precise, so use proper nouns, verbs, adjectives, adverbs and most importantly, proper scientific terms applied according to their strict meaning. For instance, replace "strong peak" by "intense peak" or "abundant ion" and never refer incorrectly to a technique such as "mass spectroscopy" instead of "mass spectrometry". Do not use "amu" as a unit of mass instead of Da, or mention "high yield" for a reaction without specifying how high this yield is. Provide sufficient but not superfluous experimental details, such as merely mentioning you characterized a product by NMR and failing to provide crucial details such as the operational frequency.
4. **Replace words by figures, symbols or units.** Whenever possible, replace descriptions of experimental details, data, set ups, quantities or trends and predictions by tables, diagrams, schemes, charts, plots, units, symbols and figures. This rule is therefore a very general one: "A picture (table, scheme, photo, chart, unit or the like) is worth a thousand words".
5. **Write manuscript sections as manuscript sections should be written.** This rule simply says: "an abstract

should simply be an abstract, nothing more than an abstract". The same applies to the introduction, results, discussion, and conclusion sections. An abstract, for instance, should be free of introductions, experimental details, data, discussions, and conclusions. It should present an overall view of what is reported in the manuscript, as 'simple' as that!

Revise your work to exhaustion. This rule says: *write the 1st draft of your manuscript and revise it for concision, clarity, and precision. Rest for a while and revise it again. To reach perfection, repeat this cycle "infinite times"*. But since you intend to submit your manuscript, repeat this cycle at least 3 times or 5 times at most!

3. More on Readers

Good readers generally become good writers. But more than ever, writers have a growing quantity and complexity of scientific information available with thousands of options of journals and manuscripts to read and in which to publish. Therefore, as discussed for decades,²⁶ due to diminishing time, scientists are increasingly motivated to avoid unnecessary reading. More experienced and profitable scientists are voracious readers who know which journals to read and where to publish.

Although selection in reading is multifaceted expertise that varies from area to area,^{27,28} some interesting manuscripts have been published suggesting some approaches to methodological scientific reading.^{29,30} For us, the most reasonable and valuable rules are:

- (i) *Read the title of the manuscript to check if it attracts you and if you would understand its content.*
- (ii) *If so, read its abstract to check if indeed the manuscript interests you.*
- (iii) *If so, during reading try to answer basic questions about the manuscript, such as:*
 - (a) *What is the main science and goals in it?*
 - (b) *Which problems does it intend to address?*
 - (c) *Which methodologies were used to reach consistent answers to the problems it presents?*
 - (d) *Why did authors run the experiments the way they chose to?*
 - (e) *What are the advances it describes and are they indeed new and relevant?*
 - (f) *What are the limitations of its data and suggested implications?*
 - (g) *What are the perspectives and new questions it raises?*

(h) *Is any important information missing in it, such as experimental details, data, analysis, or conclusions?*

(i) *What would you do differently?*

(j) *What would you do to advance the science it describes?*

(iv) *To learn more on the art of scientific writing, ask yourself whether it is as concise, precise, and comprehensive as it should be. Identify major problems and suggest corrections to yourself.*

(v) *Did you read it only once, in a fully forward mode? A wordy, cumbersome, and badly constructed manuscript demands several readings – with many returns – until you begin to grasp it, and even then, sometimes, only partially, at the end.*

If you follow these pointers, you will likely select useful manuscripts that will serve as good guides for you to hone your abilities in science and scientific writing. When reading a manuscript, always be skeptical but not excessively so. The better the data, the less skeptical you should be. Always try to compare results with other work you have read or concepts you already know. Be intellectually honest and change your concepts if new evidence points to a different direction. Science progresses via trial and error, and by better theories arising along the scientific journey.

4. Before Writing

Before you start, check a few boxes to facilitate the whole writing process.³¹⁻³³ The most fundamental question is: *do I have in-depth knowledge of the subject I am about to write about?* If your answer is "no", read and study more; otherwise, you will lack the proper knowledge that is essential to write an authoritative manuscript, risking writing a discreditable one. Advance only when your answer is a confident "yes".

Now reserve sufficient time for writing. Time for planning is very important, and the less skilled you are in writing, the more time you should allocate. This can range from a few hours to a few months. Reserving time for writing is inaccurate science, and many different variables are often involved from manuscript to manuscript. But as a tentative program, for beginners, reserve 2 or 3 h *per* day, write 1 or 2 paragraph each day, at least 3 days *per* week. At this rate, writing and revision should take 2 to 3 months, which is quite a reasonable time for novices.

Now, draft a statement to make sure you understand the goals and perspectives of your work, and the real contribution and impact it makes. This statement will

serve as a precious guide for several steps in writing a manuscript (or even a letter or review). Make sure also to have an initial list of key references to cite, but first read them again – *at least dynamically* – to refresh your mind. Make sure to have all your results to hand and understand them properly. Remember that, even if you are “merely” a co-author, you too will be responsible for the full content of the manuscript. Make sure, therefore, that you understand all results, read the full text before publication and check whether you agree with all that has been written.

Finally, remember that writing a scientific manuscript is analogous to storytelling.³⁴ Manuscripts are narratives aiming at convincing readers of the importance of the science they describe, the accuracy of the experiments and analyses performed, and the relevance of data presented. But you must also engage your readers in the text. At the end, the readers should believe the data are worth publishing, and reach the same conclusions as you did. A compelling scientific story – *the most effective way to communicate science* – should involve well-conducted and presented storytelling, guiding readers to appreciate the impact of your results and requiring therefore a beginning, a middle and an end. To captivate readers, your story also has to be concise, compelling, clear, attractive and technically sound. Logically, this task is hard even to summarize, and much more to achieve, requiring much trial and error and dozens of written manuscripts to master it.

Focusing your mind on these goals, and with your hand ready with all the data and tools, start working on each of the 7 fundamental components of the elementary structure of a standard manuscript (Figure 1). But, first, make sure you know the main characteristics of each one, so you can write these sections properly. You can choose to start anywhere you like, but we, in general, use the following sequence since each section benefits from the previous one: introduction → results (& discussion) → conclusions (and perspectives) → abstract → title. We recommend adding the references simultaneously and continuously as you write each section.

5. Basic Structure of a Manuscript

Figure 1 shows the basic manuscript structure, which began to be used systematically in the 1940s, became more popular in the 1970s, and is currently almost universally used.³⁵ Knowing the elementary structure of a standard manuscript (Figure 1), and its basic characteristics, is vital for effective scientific writing. Secondary but still important items are the list of authors and addresses, keywords, graphical abstract, acknowledgments, notes and supplementary materials. Although there is no consensus

on how these sections should be constructed, we will offer our views, gained after decades and hundreds of published manuscripts.

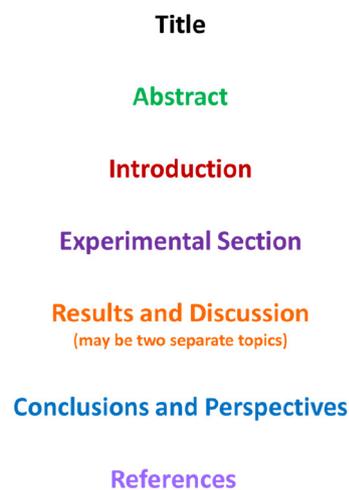


Figure 1. General view of the basic structure of a standard manuscript. Note that this structure is sometimes referred to as IMRaD (introduction, methods, results, and discussion).

6. Writing and Selecting a Title

It is certainly the shortest section, but the title is *the reader's first encounter with your manuscript*. You should therefore devote serious effort to constructing it, but titles should display many characteristics that are hard to combine. They should be short, comprehensive, attractive (but not trivial), sound, technical, informative, concise, accurate and unique and, as far as possible, fully describe the science the manuscript presents and express its relevance. When these features are properly combined, a title will fulfil its main objective: convincing the reader that the manuscript is worth reading, and sometimes even worth paying to read.³⁶

The title therefore has a great effect on a manuscript's readership and impact, via citation, and readers may overlook excellent science described in manuscripts with poor titles.³⁶⁻³⁸ General readers, reviewers and editors often associate poor titles with poor science, probably unconsciously. Editors are exposed first to the title (and abstract) of your manuscript, so poor titles (and abstracts) may lead to rejection without peer-review.³⁹

Our general advice is to avoid the use of buzzwords, such as “*superior*”, “*best*”, “*new*”, “*first time*”, “*green*” and intensifiers/superlatives such as “*very*” or “*exceptional*”, since they can potentially discredit your work.⁴⁰ Ironically, many manuscript titles have used “*new*” or “*first time*” in their titles, but on reading them, the lack of novelty or pioneering effort is glaring. The use of hot keywords

such as “nano”, “single-site catalyst”, “organocatalysis”, “multicomponent”, “single-cell”, “C–H activation”, or “biomarkers” is recommended, but make sure these terms actually reflect the content. For instance, “green” has been greatly misused in titles of manuscripts describing mere improvements in peripheral aspects of green chemistry, but their whole reported process is still deleterious and far from green. The expression “green herrings” has been coined to describe these cases.⁴¹ When using hot keywords, always remember that “*extraordinary claims demand extraordinary evidence*”.⁴² And we add:

“Too extraordinary claims will likely arouse suspicion from readers and reviewers, who will then work hard to inspect your manuscript, searching for ways to debunk your too extraordinary claims”.

Too extraordinary claims are more likely to jeopardize than boost your manuscript. Refrain, therefore, from using superlatives such as “*extraordinary, superb, superior, exceptional or ground-breaking*”. If the data you present are, for instance, indeed revolutionary, describe the revolutionary nature of your work concisely and precisely, so readers will easily recognize its exceptional nature.

Although it may be risky, and there is no consensus on this strategy, you could also try to write a provocative title by making a direct analogy to a well-known idea or concept. For instance, when writing a review manuscript on the use of electrospray ionization for proteins, a provocative title could be: “*Electrospray ionization: making molecular elephants fly*”, thus making an analogy to the speech given by Nobel winner J. B. Fenn at the Nobel ceremony.⁴³ Or when writing a paper on the distillation of ionic liquids (salts) a provocative title could be: “*The distillation of ions: making the impossible possible*”, hence indicating the controversy on how non-volatile “salty” ionic liquids can be distilled.⁴⁴ Some of us prefer provocative titles such as: “*In Melting Points We Trust: A Review on the Misguided Characterization of Multicomponent Reactions, Adducts and Intermediates*”⁴⁵ and “*Forensic chemistry and ambient mass spectrometry: a perfect couple destined for a happy marriage?*”⁴⁶

Figure 2 shows two illustrative but hypothetical manuscript titles we considered appropriate and two less so. The titles in red suffer from some common problems: (i) use of a structure name; (ii) clumsy wording; (iii) the use of “new” and excessive use of superlatives such as “*highly efficient and superior*”; (iv) excessive length (v) repetitions of “*catalysis*”, (vi) exaggerated science. The blue titles are, we judged, substantially more attractive, short, informative, and sonorous, describing the main science in

these manuscripts, albeit conservative in style. You would prefer, perhaps, to add a little more “pepper” to them.

Regarding title length, a study investigated its relationship with citations,⁴⁷ concluding that, as a general rule, short titles perform better. Although some highly cited manuscripts have long titles, people tend to read less and less, and are struggling against reading;⁴⁸ therefore, short titles seem increasingly effective. It has been proposed that titles should contain a maximum of 20 words.⁴⁹ As an example, compare these two draft versions of a title:

1,1'-((1λ³,1'λ³-2,2'-spirobi[[1,3,2]Dioxastannolo[4,5-c]pyran]-4,4'-diyl))bis(methylene))bis(3-methyl-1H-imidazol-3-ium) Chloride as a New Catalyst for Biodiesel Production

(A) An Ionically-Tagged Tin Catalyst for Biodiesel Production

Highly Efficient and New Nanometric Catalysts for Superior Hydrogen Generation by Water Splitting: Photocatalytic and Photoelectrocatalytic Processes

Water Splitting by Photocatalytic and Photoelectrocatalytic Processes at Nanometric Scales

(B)

Figure 2. Two examples of fictitious manuscript titles considered to be appropriate (blue) and some requiring polishing to become more appropriate (red).

“First on-line and real-time interception and proper characterization of five major intermediates that participate in Lewis acid catalysis using lanthanide triflates as catalysts by mass spectrometry and magnetic nuclear resonance spectroscopy: implications for the major mechanism of this process”.

Or:

“Intermediates in Lewis acid catalysis with lanthanide triflates: revealing its mechanism”.

Now think which title is better in describing the science and simultaneously attracting readers’ attention. Surely, the much longer title has too much and distracting information, whereas the shorter title serenely transmits nearly the same ideas, which are mostly implied within it.

But when should a title be written? It has been argued that a title should be kept for last,⁵⁰ whereas some have recommended it should be written first.³⁷ For its pivotal importance, we think the best is to write or to revise it at the end of the writing process, when you have consolidated all sections, and thus when you are in the best possible position to elaborate the best possible title. A nice tip on titles is to write as many alternatives as you can think of and reflect on them until you can pick out the winner, as we did for this manuscript you are reading. A key tip is: “*make every*

word in the title work hard”.³⁶ That is to say: *delete from titles any unnecessary word!*

A short, strong title followed by a more explanatory subtitle strikes many as a good idea, particularly to encompass different but crucial aspects of the manuscript. One reference author for us has published two examples of this kind: “*From Molten Salts to Ionic Liquids: A “Nano” Journey*”⁵¹ and “*The potential of palladacycles: More than just precatalysts*”.⁵² These two-part titles encompass essential information on the manuscript’s content whereas certainly attracting readers’ attention. Perhaps the title of Darwin’s seminal book may serve as another key example: “*On the origin of species by (means of) natural selection: or the preservation of favored races in the struggle for life*”.⁵³ Note also that four complementary major keywords of the book – *origin of species, natural selection, preservation of races, and struggle for life* – are included in the title and subtitle, serving to summarize the science and attract the reader’s attention on different fronts. One of us often uses this strategy, such as in this title: “*Fragmenting nanoPutians: capturing admiration for the rationality, predictability, and beauty of ion chemistry in mass spectrometry*”.⁵⁴

7. The Abstract Section

Well-written abstracts are becoming more important than ever. Abstracts (and titles) are now freely available online to all readers, so the better your summary, the better the chances of your manuscript being selected by a reader.⁵⁵ Abstracts can also be decisive when an editor is considering whether or not send out the manuscript for review. Abstracts are better described not by what they are, but by *what they are not*. Keep in mind that abstracts are not an introduction, or a description of results, or the place for discussions, or conclusions. Therefore, remove any of these items from your abstract. Proper abstracts provide a concise but comprehensive summary of the work and a very brief description of important findings. *Nothing more!*

Several journals limit the number of words for abstracts, forcing you to be concise. Although we understand that an abstract should only be a brief description of what has been done and major advances the work has provided, some journals think otherwise, requiring what some have called *structured abstracts*,⁵⁶ with subsections for introduction (or background), methods, results and conclusions. Some analyses have indicated that structured abstracts enhance impact,^{57,58} but the evidence is still tenuous. Independent of the style, follow the same writing principles, that is, be as brief and specific as possible. Since we prefer them, we will focus our discussion on unstructured abstracts.⁵⁶

A very common problem seen in abstracts is starting with a sentence that is more suitable for an introduction. Therefore, read your abstract and if you note a sentence of this kind, move it or remove it accordingly. Another common mistake in abstracts is giving experimental details such as pressures and temperatures, or a detailed list of reagents or results, such as yields and purities of products. *Bad mistake!* You should allocate this information to the experimental section or to results and discussions. References should never be cited in abstracts but, if for some exceptional reasons, you need to add a reference to it, give the reference in full.⁵⁰ References cited in abstracts are commonly found – and best justified – in “comments” and in “reply to comments” manuscripts, but it is still best to avoid them.

One excellent tip for writing a proper abstract is to remember that this section is an answer to the question: “*Could you briefly tell me what your work was all about?*”⁵⁹ Below we give two versions of the same hypothetical abstract as an example in which we tried to summarize our major points.

“Energy is essential to mankind and the search for green energy sources has recently attracted a lot of interest. Among the tested alternatives, water splitting is a promising process via which molecular hydrogen is produced from friendly feedstock and solar energy. In this work, we report our evaluation of two binary (GO-CdS) and three ternary (Pt-GO-CdS) hybrid photocatalysts for hydrogen production assisted by visible light irradiation. Cadmium sulfide and composites with GO were prepared by sonochemical and thermal methods at three different temperatures (200, 300 and 400 °C) and the same pressure of 3 atm. GO addition was done by employing two different strategies: concomitant synthesis or mechanical mixture. The first approach led to better composites since they display smaller interplanar distances and less crystal defects. The best performance in hydrogen production among all materials tested was noted for a ternary photocatalyst we named Pt(GO/CdSTT), whose hydrogen production rate was 850 mmol per gram per hour. This catalyst was obtained by the thermal method with GO addition during the synthesis. GO photoreduction during photocatalytic hydrogen evolution was confirmed by XRD and Raman spectroscopy analyses”.

This abstract has several “easily noted” problems: it is far too long, contains statements better presented in the introduction, describes unnecessary experimental and

result details that should be moved to the experimental and results sections, presents discussions of methods that should be moved to the discussion section, and fails to point (briefly) to the advances and prospects the study offers. An insightful reader may suspect the science is good and that the manuscript has described important findings, but she/he is more likely to suspect that this was not the case at all, as nothing is clearly mentioned, and therefore may abandon reading the manuscript.

We would re-write this hypothetical abstract as follows, but before you read our version, you can try drafting a better one.

“Hybrid photocatalysts combining graphene oxide (GO), CdS and transition metals for H₂ production from H₂O assisted by sun irradiation were tested. A ternary photocatalyst, Pt(GO/CdSTT), displayed excellent performance, with a production rate of H₂ at an order of magnitude superior to other commonly used catalysts. This source of green and sustainable energy will likely become commercially viable.”

From these two abstracts, which “manuscript” would you select for reading? Or as an Editor, which abstract would you send out for peer-review? Or even as a reviewer, which one would you recommend for publication?

8. The Introduction Section

The most important and most neglected characteristic of the introduction is that *it must not be a review*. Some manuscripts have such long introductions with so many distractions that readers – *those whom you worked so hard to attract in the title and abstract* – quit reading the manuscript while struggling through the introduction. As it has been indicated,⁵⁹ beginners often believe they should start introductions with “*J. J. Thomson’s discovery of the electron...*” and go on to craft a chronological narrative until they have fully explained the current knowledge in the field. But the best introductions, rather than providing such historical reviews, should briefly contextualize – *in a few paragraphs, let us say 2 to 4* – the science and the problem faced, showing how important this specific study is to the field. This aspect of the introduction plays a key role in scientific writing. But well-written introductions should do more: they should have a “magic” effect on readers, making them feel captivated by the science and the advancements that the study promises to offer, thus motivating overall engagement with the manuscript. When reading the introduction, readers should feel a growing scientific curiosity. Poorly written introductions not only lessen the

readers’ interest, but could potentially trigger misleading interpretations of the content of the manuscript.⁶⁰

Therefore, an effective introduction typically:

- (i) *Concisely but comprehensively presents the scientific or technological importance of the field.*
- (ii) *Discusses major gaps in knowledge addressed by the current study.*
- (iii) *Cites major references related to the study, mostly important recent reviews, and milestone or pioneering manuscripts.*
- (iv) *Ends with an attractive and brief description of what is going to be presented, after you have convinced your readers that the whole manuscript is worth reading, but never ends (as introductions often do) with a summary of the results. You risk losing your readers. Give them this information later in the respective sections.*
- (v) *Organizes readers’ thoughts by discussing one topic per paragraph. Never write about a topic in one paragraph and come back to it in another.*
- (vi) *And above all: Never add to the introduction anything that could be moved to the abstract, results, discussion, conclusion, or perspectives.*

Regarding length, introductions should never be more than a few paragraphs (2 or 3 at least and 6 or 7 at most), regardless of the type of manuscript. But the length also depends on many factors and may vary accordingly. If you are writing a full paper in an interdisciplinary field – for instance, when you have monitored a multicomponent reaction with a new mass spectrometric technique – you likely need to write about different areas and concepts; therefore, a longer introduction is justified. Communications or letters demand the shortest introductions.

9. The References Section

Since they contextualize the work, we should cite most references in the introduction. A few other references will be cited in the experimental section, often as references to experimental procedures, or in the discussion during comparisons with previous studies, or in the conclusion (and perspectives) when making or comparing predictions about future applications.

For organization, we strongly recommend using reference management software. These tools greatly facilitate citation management, application of a journal style, and sharing references.⁶¹ They also allow you to organize, classify, tag and annotate in-text citations as well as fetching up documents, and ease the automatic import of

references with all the relevant information such as authors, abstracts, and keywords from scientific databases.⁶² These software tools are so powerful that it is fair to say that if you choose not to use them, you lose precious time and energy. These tools also prevent you from inserting the same citation twice!

For reference selection, the two most fundamental questions are: (i) which references and (ii) how many references should one cite? Recently, a trend toward an exaggerated citation of reviews appeared, creating a “review citation bias”. Using review manuscripts works perfectly when citing a general area such as multicomponent reactions, green chemistry, mass spectrometry, palladium catalysis, or ionic liquids. But the original reference is still preferred when citing a specific finding such as a specific catalyst. Therefore, have no preference either for reviews or original manuscripts, but cite them appropriately.

Finding proper reviews or original manuscripts is an increasingly hard task due to the increasing volume of scientific literature.⁶³ The only alternative is, therefore: read much as you can and search as much as possible for proper literature, knowing that – *as years go by* – this task is likely to consume more and more of your time.⁶⁴

Proper citation is fundamental for authoritative writing, since it provides a solid basis for your own writing, and additional resources for readers.⁵⁹ Citing manuscripts closely linked to the origin of the topic discussed is fundamental, but also cite the most recent manuscripts to demonstrate the area is active and also to give an overview of its current status and directions.

When citing a reference, you should directly correlate it to the subject for which you cited it. But as has also been pinpointed,⁵⁹ it is unfortunately common that we check a reference only to find that it has no connection at all to the linked subject. Avoid this mistake or misconduct. As estimated before,⁶⁵ authors on average read less than 23% of the references they cite. Avoid therefore this low-key misconduct.⁶⁶

But how many citations should be cited? The answer is unfortunately not as clear as we would wish. The fairest strategy would be for you to cite all the relevant literature, but of course, this may be impossible or not allowed. Choose therefore the ones you judge as the best, *after reading them!* Studies have also indicated an imprecise relationship between the number of references and the number of citations a manuscript will receive.^{67,68} Some journals make our lives ‘easier’ by limiting the number of citations. Reviewers usually request additional references, so leave room for them. As general advice, it is fine to cite more than 100 manuscripts if they are indeed needed, but

a large number of references fails to function as a criterion of excellence. Authors believing that “*the more citations the better*” have created a trend toward a larger number of references, but we agree with a warning recently given: “*If this trend were to continue, would most manuscripts effectively become reviews?*”⁶⁹

Self-citations (citations of your own work) are acceptable, but only when they fulfil the criteria of best or essential references. Excessive self-citations do no good in demonstrating how expert or productive you are, but as has been pointed out,⁷⁰ they often produce the negative effect of showing that you are probably disregarding the work of others. An editorial⁶³ has suggested that self-citations, regardless of how much you properly cite them, should not exceed 20-25%. Some journals demand less than 10%. Apparently,⁷¹ self-citations have an influence over citations from others, and this is perhaps one of the most important reasons to explain why some authors have a high self-citation count.

Unpublished materials must be cited sometimes, but do your best to avoid them. Some publishers, when they cite unpublished materials, request that the authors upload these materials, so reviewers can see them. Other publishers ask to use these citations only in the main text and refer to them as “*unpublished observations*” or “*personal communications*”.

A final tip: never cite manuscripts from “predatory” journals.⁷²⁻⁷⁷ A broad definition of predatory journals⁷⁸ is: journals published by “*entities that prioritize self-interest at the expense of scholarship and are characterized by false or misleading information, deviation from best editorial and publication practices, a lack of transparency, and/or the use of aggressive and indiscriminate solicitation practices*”.⁷⁸ The task of identifying such journals is often hard, so even experienced researchers have already cited, and worse, published in such journals, after being duped by predatory strategies.⁷⁸ But if in doubt, ask for advice, and do your best to avoid submitting to or citing them.

10. The Experimental Section

Again, this section should be free from materials suitable for the abstract, introduction, results and discussion or conclusion sections. A well-written experimental section is the key to reproducibility; therefore, it should describe concisely but as comprehensively as possible the experiments and measurements you have done. It is perhaps the most tedious to write, but this section is closely and indissolubly allied to the manuscript quality. Readers and reviewers often associate poorly written experimental sections with work done with little care. It is unethical to

hide any detail necessary for the work to be reproduced. As it has so rightly been stated:

*“One of the greatest compliments anyone can give your published work is to reproduce it and build upon it. Your discovery starts to take on a life of its own, which is one of the strongest indicators that your work is meaningful, broadly speaking, to the scientific community”.*⁷⁹

Manuscripts with careless writing in the experimental section can result in corrections (publishing of a corrigendum), or even worse, retraction. When writing an experimental section, bear in mind that what is clear-cut for you who performed the experiment may be completely obscure for those trying to reproduce it. You should *be therefore as clear as you can!* Imagine yourself conducting (or reproducing) the experiment for the first time, with the limitation that you can only rely on the information provided in the written text.

As a picture is worth a thousand words, as far as possible, use schemes, diagrams, charts, pictures, symbols, units or even videos (in supporting information) to replace long, unusual, hard-to-describe or too intricate procedures. Keep in mind that your audience is formed by skilled workers, so never exaggerate on the details such as describing preparation of samples for NMR analysis, evaporating solvents in a rotary evaporator, or how you have used a scale, and what scale you have used to obtain mass.

It is also crucial to inform readers about which specific instruments you have chosen and how you have used them to acquire your data.⁸⁰ Brands, models and major set-ups should therefore be provided, but only for specific and more specialized instruments. Important details such as an NMR frequency and m/z ranges, or accuracy and resolution in MS analysis should also be included. Keep in mind that equipment manufacturers and models are frequently irrelevant, but operational details are crucial. A comprehensive analogy would be the description of a cooking recipe that correctly describes key ingredients, quantities, recipe volume and cooking time, but does not provide the brand of pan used or how to break an egg or measure a certain volume of milk.

Since *less is more*, save space by using the units for common quantities or abbreviations for common techniques such as °C for temperature, g for grams, m/z for units of “mass of ions”, MS for mass spectrometry, and NMR for nuclear magnetic resonance spectroscopy. There is also no need, for instance, to say that “the reaction was performed at a temperature of 100 °C, a pressure of 5 atm under an inert atmosphere of nitrogen gas (N_2)”. “Skilled

readers” know that 100 °C refers to temperature, 5 atm refers to pressure, that nitrogen is an “inert” gas, and that the chemical formula for nitrogen is N_2 . So, write “the reaction was performed at 100 °C and under N_2 at 5 atm”. *Be precise, but concise!*

11. The Results and Discussion (R&D) Section

Now it is time to write about findings. Ultimately, it is in this section that readers and reviewers will judge if you – *logically, concisely, and intelligibly* – present worthy reading and worthy publishing results. In the R&D section, we should also convincingly present answers to questions raised in the introduction, guiding or inspiring future experiments by others.⁸¹ Some journals require that R&D is presented in separate R and D sections, but this is not a great change at all. If you write a combined R&D section but are later asked to split it, just extract the D sentences leaving the R text behind. The R section presents raw data such as graphics, diagrams, schemes and tables, while the D section evaluates whether the provided data supports your hypothesis.

R&D are not a chronological presentation of events; therefore, select the order that best fits your scientific story. R&D should thus be written as an interesting and attractive possible sequence of texts, tables, figures, schemes, and diagrams, which provide logical reasoning that culminates in a rational conclusion of the data presented. As stated elsewhere,⁸² the discussion should allow readers to engage with the data and agree with the findings and conclusions. Why you have selected experiments should also be clearly presented in the R&D section.

Strengths and weaknesses of the study should also be clearly stated,⁸³ but in general, authors tend to write enthusiastically about positive results and just *en passant* about failures and limitations. Try to be fair and discuss them both with the same tone. This attitude will show readers and reviewers you took a critical view of your work, not undermining your manuscript, but boosting it.

Other key tips to R&D are:

- (i) *Compare your results to previous ones, discussing the improvements, novelties, impact and limitations of your work and that of others, highlighting the most contrasting results or conclusions, particularly in controversial fields.*
- (ii) *Give preference to tables, graphs, schemes, charts and figures.*
- (iii) *Avoid unnecessary criticism of others, controlling the scientific bias we all have, and expressing all sides of the story without passion or personal*

feelings.⁸⁴ A critical appraisal requires logical and analytical thinking, but it does not call for criticism at all.

- (iv) *Never repeat any data or discussion. If you describe conditions for a reaction in a table or figure, refer to it instead of rewriting them. Details are found in the experimental description. Avoid using data already provided in a table, for instance, to make a plot. Refer to the table.*
- (v) *Move to supplementary material any data that are not essential (or even superfluous) to the discussions and later, to the conclusion.*
- (vi) *Never speculate without proper evidence; that is, never go beyond what is allowed by your data.*

By the end of the R&D section, you should have satisfied your readers by providing results and necessary discussions; and they should be ready and eager to hear the overall conclusions and perspectives arising from your well-written work.

12. The Conclusion (& Perspectives) Section

Your job is almost complete now, only missing the “*grand finale*”: *a concise conclusion tempered with future prospects!* A common error that must be avoided in the conclusion section is to summarize results and discussions already presented. *Nothing is more tedious to editors, reviewers, and readers than that!* Carefully inspect your conclusion and remove from it anything that could be classified as results and discussion, or as belonging to other sections. This is where you clearly and briefly expound how your findings have contributed to expanding the field and the implications of your work.⁸² *Nothing less, nothing more!* In short, the major rule for a conclusion is: *write not what you have done but what you have found and where your findings lead.*

The conclusion section must be in general short! Long conclusions tend to contain unnecessary results and discussions, or excessive predictions or useless and deprecating speculations. As a general rule, if you write a conclusion section that is more than 1 or 2 paragraphs long, *revise and cut it.* Inter- and multidisciplinary manuscripts require conclusions that align with the overall tone and content of the manuscript. Concise conclusions should not be misconstrued as poorly written or weak that undermine the substantial effort invested in the entire work.

A well-written conclusion also leaves a lasting and positive impression on readers via words of sober enthusiasm about your findings and how they served to

advance science. It should also motivate others to keep building on the grounds you established. We provide below a very short conclusion section, for a hypothetical paper titled “*The Heck reaction: intermediates and major steps via mass spectrometry charge-labelling and ion fishing*”. It serves, obviously, just as a general guide, for you to have a feeling for the style we recommend. Of course, opinions vary and you may also elaborate your own and better version for this section. *Give it a try!*

“The intricate mechanism for the pivotal Heck reaction has therefore been disclosed, with major intermediates intercepted and well-characterized owing to the efficacy of charge tagging and the on-line real-time fishing of ions by MS. These findings allow for a more realistic elaboration of all reaction steps, which could guide further attempts to improve the speed and yields of Heck reactions via proper catalysts. Similar investigations of other variants should provide a deeper understanding of the mechanism of this pivotal transformation in synthetic chemistry”.

13. The List of Authors

This is the most “electric” task when writing a manuscript since it can and quite often does produce strong “short-circuits”. In setting up the list of authors, you should give credit to all those involved in planning, collecting and discussing the data, or elaborating conclusions, even sometimes to those who have provided key samples or guided you, due to long-term expertise, in the proper operation of intricate instrumentation. But the difficult question is how to “calibrate” the threshold of credits. How much is enough? It has been indicated⁸⁵ that authorship is known to involve human elements that are hard to quantify objectively. Especially nowadays, science has become highly collaborative (interdisciplinary), thus generally requiring the contribution of many people to different aspects of a work.⁸⁶

Avoid “ghost authorship”,⁸⁷ but when in sincere doubt follow this rule, similar to a common one in justice: *“never add a credit-free author, but it is better to add an author with too little credit than to leave out an author with enough credit”.*

We also think the senior researcher who acted as the work supervisor should be listed last (or sometimes first) with the “*” (starred name) to indicate leadership and action as the corresponding author. In collaboration works between different groups, we think that all supervisors should get starred names, as in this very article. The first author is normally the person who was mainly responsible for the progress of experiments and data collection.

Within your text, refer to the surnames of all authors for manuscripts with up to 3 authors, but when citing a manuscript with more than 3 authors, instead of the surname of the first author followed by “et al.”, prefer to cite the surname of corresponding authors followed by “co-workers”. Science has a general hierarchy structure that should be followed, and although credit for a manuscript is divided by all authors, most credit should go to advisors. Therefore, and for instance, instead of “Neto *et al.*” prefer “Suarez and co-workers” when nominally referring to a manuscript with a list of authors such as: “Neto, B. A. D.; Alves, M. B.; Lapis, A. A. M.; Nachtigall, F. M.; Eberlin, M. N.; Dupont, J.; Suarez,* P. A. Z.”⁸⁸

14. The Graphical Abstract (GA)

The GA is also of vital importance nowadays. The GA is an image that portrays the scientific content of the manuscript. As an image, *it worth a thousand words and data!* The main purpose of the GA is to attract readers' attention to your work while summarizing it, in a single but comprehensive image.⁴⁰ The design of an excellent GA is usually a hard task.

Today, there is also one very important aspect of the GA that requires attention, that is, the use of it in social media to share scientific findings, and its fitness is currently debated.⁸⁹⁻⁹¹ As experienced reviewers and editors, we have noted a few common mistakes in published GAs. Sometimes it is a copy-paste version of a manuscript figure. Others are so crowded with images or populated with so many colors that they scare readers away rather than attracting them.

Since the GA “*will be the first glimpse a potential reader will have of your work*”,⁹² it must therefore be truly a work of art: pleasant to see and scientifically sound; and it should positively influence the reader's decision to click on your manuscript link. An elegant GA is also perfect if you intend to share it in any social media, thus expanding the visualization of your work, although the strategy may be fruitless.⁹³ When designing a GA, consider these tips:

- (i) *It must be closely connected to the title and, therefore, to the results presented.*
- (ii) *It should be flashy, but not frivolous.*
- (iii) *It should transmit ideas mostly via figures, not words.*
- (iv) *It must be artistic (eye-catching), but not trivial, thus keeping its technical-scientific nature.*
- (v) *It should guide the reader to understand what you have done and, if possible, what you have found or achieved.*

Indeed, a GA demands much effort and talent, but it is like driving F1 cars: *you will most likely never drive as spectacularly as Ayrton Senna did, but you must keep trying!*

15. Tables, Schemes, Figures, and Others

You will certainly communicate science more effectively using tables, figures and graphics. Therefore, in science too, “*a picture is worth a thousand words*”. Tables and images are very effective ways to summarize data and ideas, particularly the more complex and extensive ones.^{40,94} But readers should be able to clearly see and understand them, so never use low-quality figures, especially nowadays with so many imaging tools available.

Regarding legends and captions for figures, they should ideally just inform the reader what the figure is about. A common but unnecessary practice is to discuss in the legend the particularities of the data shown or what findings that figure helped to obtain. Say for instance: “*Figure 1. GC/MS of corn oil*”. That is sufficient. Never go on to give excessive details in legends to figures such as temperature ramps or type of instrumentation used to collect the GC/MS data, or how many peaks were detected. Do not use the legend to present the conclusions the figure leads to. Write all of these in the specific sections referring to the corresponding figure.

Since some journals often limit the number of figures, use this powerful tool with wisdom and parsimony. If the manuscript demands more, show these additional figures in the supporting material. Use contrasting colors and shapes,⁹⁵ particularly today that the use of colors in manuscripts has become free of charge in most journals, so unless you wish to order printed copies, go for colors. But we have learned not to exaggerate in colors and tones, since a study has demonstrated that a limited color palette is indeed more effective; and that black and white figures may sometimes be even more effective.⁹⁶ What to do, then? Well, the primary function of color is to convey information, so use black and white figures if you discover that colors in your picture are providing no information at all.

Today, figures have to be displayed in an appropriate resolution to facilitate their interpretations; hence, low-quality figures are unacceptable. Overlapping images and graphics only indicates negligence. This is a common mistake and it should be strongly avoided. Ask yourself if all figures have been built with thoroughness, clarity and quality, and if they clearly communicate what you intended to show.

16. Preparing the Supporting Information File

Supporting information (or supplementary material) is a peer-reviewed and relevant material directly associated with your manuscript, and it is published alongside it. It is a nice addition since it may contain videos and other file types (e.g., CIF for crystal structures). These extra materials are intended to provide not crucial but additional information to help readers understand, reproduce, or even confirm information from your work.⁹⁷

Consider therefore moving items such as non-essential spectra, tables, figures, Cartesian coordinates of calculated structures, complementary experiments and additional experimental descriptions to the supporting information. These materials usually have no size limit, so use them freely. One of us have, for instance, recently published a manuscript with nearly 400 pages of supplementary material.⁹⁸ The amount of data provided in supporting information is growing due to an increase in research complexity and multidisciplinary alliances.⁹⁹ *Whenever possible, make the raw data available to readers, at least upon request.* Providing well-composed and organized supplementary material will bring more credibility to your work, and therefore facilitate its acceptance.

17. Selecting an Appropriate Journal

Now that your manuscript has – we hope – been well written, you should select the journal to which submit it. For experienced researchers, this is usually a simple task, and this will also become easier for you as you advance in your career. Selecting a suitable journal is vital, since you ought to select the best possible forum to disclose your findings. But this selection should preferably be done before writing, since most journals have their own specific styles and restrictions. Above all, the selected journal should be within the scope of your work. As we agree and advise, since “*we live in a jungle filled with a bewildering variety of predatory publishers*”,¹⁰⁰ you should prefer traditional journals produced by recognized and serious publishers. Take as an example this manuscript. We decided to submit it to the *Journal of the Brazilian Chemical Society* (JBCS) since there is no doubt that JBCS is serious, respected and long-standing. Recent manuscripts provide guides against predatory strategies and how to identify such publishers.^{72,101}

The impact factor (IF) of the journal is another key factor to be considered, but this should not be a determining factor. Predatory journals have manipulated IFs, which serves as another compelling reason to exercise caution when relying on this indicator. Indeed,

we agree that “*the hypocrisy inherent in choosing a journal because of its IF, rather than the science it publishes, undermines the ideals by which science should be done*”.¹⁰² We agree that IF is secondary, as many highly cited manuscripts – *that target the right audience* – have been published in low-IF journals. Your manuscript quality has to be at the same level of the IF of the selected journal.^{103,104}

If you are a beginner and, after searching exhaustively for journals, are still in doubt, ask an experienced researcher for a few suggestions for the best journals. You will move a few steps forward in scientific experience, but always strive to develop your own skills in journal selection.

18. Cover Letters and Response to Reviewers

Now you have finished the writing of your manuscript and have selected a journal to submit it, it is time to write the cover letter. The importance of cover letters has been debated, even among the authors of this manuscript. For some, the cover letter is of paramount importance because some editors use them to decide to send your manuscript out for review or not. If this is true, you should incorporate “*information about the thing it is sent with*” in a cover letter,¹⁰⁵ plus the significance of your findings and a justification for why you have chosen that journal. Therefore, a cover letter should not be a redundant document repeating what is already in the abstract.

But some have argued against cover letters,¹⁰⁶ since they are in general no more than an unnecessary repetition of what is provided in the abstract and/or conclusions, “*looking like ‘misleading’ commercial ads*”.¹⁰⁶ Others have expressed different opinions stating that cover letters are “*a very useful exercise to write a good one – not for its own sake, but as a stimulus for the last acts of optimization that you perform before submission*”.¹⁰⁷

If you decide to give much effort to this letter, keep in mind it ought to be simple and short.^{107,108} Editors will likely develop a negative view of your manuscript if they are “forced” to read long cover letters with mere repetitions of abstract and conclusions. As Editors, we sometimes see cover letters with 3-5 pages, although fortunately they are not in the majority.

If you are submitting a revision of a reviewed manuscript, you should then write a second letter with “responses to reviewers”. When writing it, remember that if the Editor sent the manuscript back to you, independent of whether it was for “major” or “minor” revisions, it is because the Editor believes your work has the potential to be published. Take this 2nd letter therefore as an

opportunity to show clearly and politely to the Editor how you have responded positively to reviewers' comments and criticisms, and how you have improved your work accordingly.¹⁰⁹ Irritable responses will not help your case, whereas *“rebutting comments in a respectful way goes a lot further”*.¹¹⁰ But do not be afraid of disagreeing with reviewers, since this is the “fuel” of science. To facilitate the editors' evaluation, copy each comment into your letter and reply to each immediately after the comment. Be concise and direct. *Long rebuttals only demonstrate that the criticism was indeed valid and probably correct.*

Another helpful tip is to avoid emotions, especially when emotions are running high. If necessary, wait a few days to digest the comments and criticisms and always try to look for their positive side. Whenever possible, try to do what is asked, or provide a sound reason against it. Today, in some journals, reviewers' reports and replies from authors are published alongside the manuscript.¹¹¹

19. Writing an Appeal (If Necessary)

If your manuscript is rejected, with or without review, you can appeal. When writing an appeal, you should follow a few pieces of advice:

- (i) *Critically reconsider the quality of your work and write an appeal only after re-convincing yourself that your work is worth publishing.*
- (ii) *Read all reports carefully and verify if the arguments against publication were indeed scientifically sound.*
- (iii) *Ask yourself if the manuscript has truly been submitted to the most appropriate journal. Keep in mind that some journals demand strong recommendations from all reviewers to accept a manuscript.*
- (iv) *Ask yourself if your work has both the required novelty and impact compatible with the journal you have selected. You may eventually discover that a wrong decision has been made.*

But if you are still “keen to battle”, copy each comment and write a polite, authoritative, critical, technical and compelling rebuttal. Make it short and concise while emphasizing to the editor the reasons why you disagree with the decision made without peer-review or based on criticisms from reviewers. If the editor changes his/her mind, congratulations! You are among the very few who succeed in this endeavor! But this is rarely the case, especially with prestigious journals.¹¹² Therefore, although some publishers allow additional rounds of appeals, if

you get a 2nd “no”, just move on and use your energy in sending your improved manuscript to another journal. Often, very well-written manuscripts with very proper and comprehensive data are the products of many rejections before final acceptance.

20. Writing Styles and Non-Native English Speakers

Eventually, every writer will have to develop their own personal writing style. For titles, for instance, some experienced writers prefer colons in titles whereas others hate them. A study of publications in the *Lancet* journal showed that colon-containing titles are in general more cited.³⁸ Another study indicated more students and academics prefer colons in titles.¹¹³ Yet another article showed a negative impact on citation for long titles and a positive effect for colons in titles.¹¹⁴ A different study¹¹⁵ indicated the use of colons in titles is more related to the field of research or country culture. Note, therefore, how much discussion manuscript styles have raised, even for a simple issue: colons in titles.

For stylistic issues, should a manuscript be written in the active or passive voice? First or third person? Singular or plural? In the past, writers used the passive voice far more frequently and personal pronouns had to be avoided.⁴⁰ But currently, the active voice is increasingly preferred and encouraged.^{12,40} A recent study⁵⁷ indicated that highly cited groups generally use the first-person pronoun plural, such as *“we report”*, rather than *“it is reported”*.

For sure, good style demands the correct use of verbs, adjectives and sentences structures, but this is a challenging task, especially for non-native English speakers. It is crucial, as small changes may completely alter the meaning of a word or a sentence.¹¹⁶ So always try to check the meaning of every “suspicious sentence” before submission.¹¹⁷ For Brazilians, in particular, tips to improve their writing in English have been published.^{118,119} You can probably find similar publications with precious tips for your native language too.

Manuscripts are often rejected due to poor English,¹²⁰ so good science is not always enough to publish. Still, good science has to be efficiently and accurately communicated.¹²¹ If editors or reviews complain about the quality of your English, do not get depressed and remember what has been stated by some experienced native English-speaking researchers: *“Perhaps you will need time, grammar books, or a professional editor to help you correct your clumsy phrasing, but you know what? So will most of your English-speaking peers”*.¹²¹

21. Artificial Intelligence (AI) and Scientific Writing

AI seems indeed to be an useful tool in science,¹²² although many of its ethical aspects are still debated.¹²³ It is also promising as a tool for teaching and learning scientific writing.¹²⁴ We have asked in the freely available ChatGPT (Open AI)¹²⁵ the following question: “What do you think about scientific articles written entirely by AI”? And the answer was indeed revealing and interesting:

“As an AI language model myself, I think the concept of scientific articles written entirely by AI is fascinating. However, it’s important to note that AI-generated articles should be treated with caution and not accepted blindly as credible scientific research.

While AI can generate text that is coherent and seemingly structured, it lacks human judgment, creativity, and critical thinking. Scientific research requires not just the ability to generate text, but also the ability to analyze data, draw conclusions, and make original contributions to the field.

Therefore, AI-generated articles can be a useful starting point for researchers, but they should always be reviewed and verified by human experts before being accepted as credible scientific research. Moreover, scientific research is often the result of teamwork, and the input of a variety of experts, including domain experts, is necessary to ensure accuracy and reliability”.

We enjoyed the answer since it was fully compatible to the concepts of scientific writing we detail herein. Indeed, scientific writing is a hard-to-master art that demands so much time and training that it requires nothing less than the most powerful, currently unbitable source of intelligence on Earth: the human brain (and mind). Even the most powerful computers cannot do better than you if you decide to learn to write with excellence. You may therefore use AI as a guide or support, but your creativity and knowledge are still indispensable and major ingredients of scientific writing. AI seems most attractive in final proofreading, since it can suggest clearer and most effective sentences, but the final decision should always be made with the guidance of your unsurpassed well-trained mind!

A few advices are recommended for the ethical use of any chatbot (or any AI tool) when writing scientific manuscripts:

(i) *Always acknowledge the use of AI tools. The Experimental and Acknowledgments sections are adequate places to do so. If necessary, provide prompts*

- or questions used for the information generation, at least as supporting information. Be clear!*
- (ii) *Text generated by AI tools should not be used without attribution.*
- (iii) *AI tools are not accountable for any ethical breaches. You are responsible for all content in a manuscript with your name on it.*
- (iv) *Although it may seem awkward to most of us, some have included ChatGPT as a co-author.^{126,127} AI tools are nothing more than tools developed, in principle, to assist us, and therefore should not be listed as co-authors.*

We are sure about the rapid development of AI tools and anticipate numerous intense ethical debates to arise regarding their use. However, although it can be “fun” to use chatbots sometimes, several ethical concerns and problems associated with these tools are making the scientific community remain alert.¹²⁸ For example, ChatGPT has created references and provided inaccurate information to complete some tasks. One of the most worrisome problems is that AI tools are capable of stifling your creativity and critical thinking. Do not let it happen.

We will conclude this section with an example we deemed appropriate. The two authors of this manuscript are not native English speakers, and the manuscript was entirely written by us but proofread by a native English speaker (see the Acknowledgement section). However, we decided to test ChatGPT as a tool for proofreading this specific section of the manuscript. The chatbot suggested changes to improve the accuracy of the text, and we agreed that in most cases, the readability and grammar improved. For a few sentences, however, we disagreed and kept our original writing. This aspect is indeed very interesting as it can help facilitate accurate writing for non-native English speakers. You are responsible however for checking the final result and deciding whether you agree with any changes made or prefer to keep your original sentences.

22. Concluding Remarks

Good science deserves the clearest, most concise and high-quality presentation as possible. But scientific writing is an art that demands a lot of practice and energy. No one is born knowing how to write a scientific manuscript perfectly, so keep trying and learning! You will eventually make it to the top! You will master the art of writing after much dedication, patience, practice and time. And by developing a style of your own! Of course, knowing the basic principles and tips, particularly learning from those who have already run this marathon, will help a lot by

providing a solid foundation from which to advance. That was the main goal of this guide: to make science better by sharing the basics of top scientific writing as we know it.

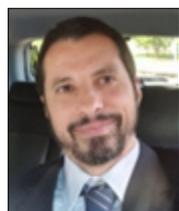
The path is indeed full of tough obstacles, but the incomparable joy of receiving an e-mail stating “*your manuscript has been accepted for publication*” is much greater and fully worth it. If you get a “manuscript rejected” email, remember that even Noble laureates¹²⁹ have sometimes had a long history of rejections. Use them just to learn more and to become even more resilient, doing your best to prepare an “unrejectable” improved paper. See, for example, the innovative publication of Professor A. Suzuki. His work was originally rejected and, after its publication, it rendered a Nobel Prize.¹²⁹ Get therefore inspired and motivated to turn your manuscripts also into award-worthy works of scientific art. They may be promptly accepted or many times rejected, but get all your manuscripts finally accepted! *Fight the good fight, finish all races, keeping the faith that good science always prevails!*

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Author Contributions

All authors contributed equally to the writing of this manuscript, with all its ideas and insights.



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