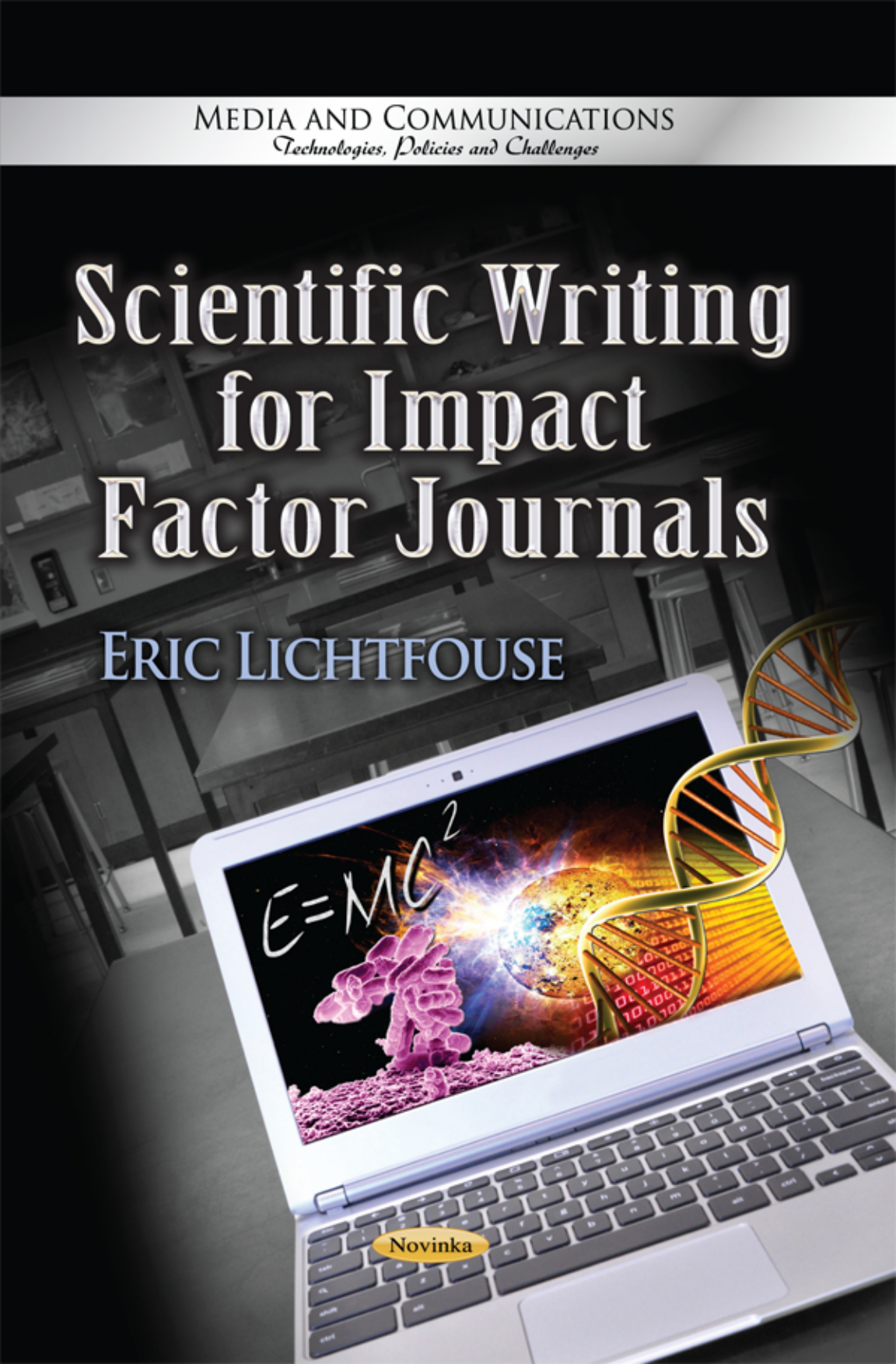
MEDIA AND COMMUNICATIONS
Technologies, Policies and Challenges

Scientific Writing for Impact Factor Journals

ERIC LICHTFOUSE



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ERIC LICHTFOUSE

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CONTENTS

But in science the credit goes to the man who convinces the world, not to the man to whom the idea first occurs.

Sir Francis Darwin

If he was to try to get a job as a researcher, God himself would be rejected. Although he carried out a very interesting experiment, no-one has ever managed to replicate it. While he explained his work in great detail, it was a very long time ago, the manuscript wasn't even written in English and since then he hasn't published anything else.

Hubert Curien

FOREWORD

GOOD WRITING IS HARD WORK!

As a young researcher or doctoral student, you are convinced – as I was when I started my career – that the point of research is to conduct experiments and obtain 'good' results. You have probably not been trained in writing because there is little systematic training available. You also think that writing an article can wait until the end of your thesis or project. You are equally convinced that all this will just happen. Unfortunately, you are very wrong. Writing a good scientific paper is extremely difficult and takes a lot of time. By comparison, carrying out experiments is relatively simple: once the hypothesis is formed, there isn't much else to think about. Writing, however, requires intense mental work. Not only do you have to write clearly and concisely, but you also have to distil the essence of your results and prepare a manuscript that demonstrates an advance on current knowledge and is worthy of being called a research article. All of which implies that you must give some thought to what is new about your work as soon as you have your first results and not after three years of carrying out experiments.

At the end of your thesis, you will be overwhelmed by your results and will not know where to start. It is quite likely that you will not be able to tell which of your results are new. With no publications to your name and pressed for time, you try to dash off an article in order to meet your institution's requirement that you have at least one publication before you can defend your thesis. And your article will probably be rejected. The rejection rate of good journals is rarely below 70% and the selection process is harsh, anonymous and ruthless – because scientific journals, like researchers, face strong global competition. Editors who publish articles that do not clearly demonstrate a scientific advance decrease their journal's impact factor. In turn, a lower

impact factor in the journal 'hit parade' reduces the quality of new submissions. Caught in this vicious circle, it becomes even more difficult for the editor to publish good articles. Even worse, a lower impact factor reduces the number of subscriptions. This has a direct effect on the job security of staff employed by the publishing house.

This book offers some tips that will both save you time and increase your chances of being published. These tips are based on my many years of experience in the field that have included the editing of many thousands of articles.

WRITING IS NOT AS IT USED TO BE

As an experienced researcher, you are convinced – as I am in the middle of my career – that you have mastered the art of writing, despite an education system where being both a good scientist and a good writer seem to be contradictory skills. You have, of course, had no training in scientific writing in English but you've learned on the job. Obviously, you are annoyed when a journal rejects your article because it is too long or the English is poor, without any detailed explanation of exactly where the problem is. But why worry? You can submit it again to a less demanding journal. Anyway, you're convinced that now you've mastered it, you do not need any further training in writing.

You are mistaken because writing is changing rapidly. The fact that communication now happens via computer rather than paper means that your writing must also adapt. Writing isn't as it used to be! You are also mistaken because your difficulty with English is, in reality a cultural disease found in speakers of foreign languages and not simply a matter of poor translation. You naturally prefer long, rambling, colourful sentences, full of figures of speech.

This elaborate and meandering style, probably inspired by the literary greats of your culture, is unfortunately totally inappropriate for a scientific paper written in English. This linguistic habit is difficult to correct because it is the language you grew up with. Therefore, I have gathered together some guidance to help you to change your habits and adapt your writing to the changes brought about by information technology. I know you already have far too much work to do, but if you follow the advice given here you will save yourself time and have a better chance of being published in prestigious journals which is, after all, the goal.

Table I. Types of scientific documents. Although there are many different types, they all aim to communicate new information effectively

SCIENTIFIC DOCUMENTS		
TYPE	AVERAGE SIZE	AIM
Training report	15 pages	Education
Industrial report	30 pages	Research, development
Expert report	20 pages	Analysis of knowledge to support decision-making
Thesis	200 pages	Research, education
Book	100 pages	Education, dissemination, research
Patent	5 pages	Protection of a technical innovation
Research article	10 pages	Presentation of primary, original results in a specific domain
Review article	20 pages	Review of knowledge in a specific domain
General article	1 page	Educating the wider public
Preface, editorial	1 page	Short summary of an issue or a book
Press release	1 page	Brief information for a broad audience
Covering letter	1 page	Job application, article submission, other requests
Curriculum Vitae	2 pages	Career summary
Marketing material	Short	Commercial document
Facebook, blog, website	Variable	A document published on the Internet with varying degrees of visibility
Tweets - Tweeter	140 characters	A very short text for social networking: an example of concision
Video, e.g. YouTube	Variable	A film showing experiments, presentations and other scientific items

Although this book is aimed specifically at researchers who aim to publish primary or original research, the principles described here apply to most scientific manuscripts. Despite the wide diversity of scientific documents (see Table I), they all share the goal of quickly and effectively communicating a new result, whether it is an innovation, a practical or theoretical advance, an invention or an advance on existing knowledge. In addition to classical documents such as the thesis or research article, other manuscripts such as the *curriculum vitae*, marketing material or product labels make a significant contribution to science. How well the science is expressed will inevitably determine the effectiveness of the document – a new job in the case of the *curriculum vitae*, or selling the product in the case of marketing material.

If you are really in a hurry, you can find the most important messages you need to take away in Appendix 1, ‘The Ten Commandments of writing a

research article' (p. 71), while Appendix 2 (p. 72) lists the main steps involved in preparing an article. For some light relief I recommend the following two articles that provide a humorous take on the common difficulties scientific authors encounter and the use of impact factors.

Sand-Jensen, K (2007) How to write consistently boring scientific literature. *Oikos* 116: 723–7. See Appendix page 73.

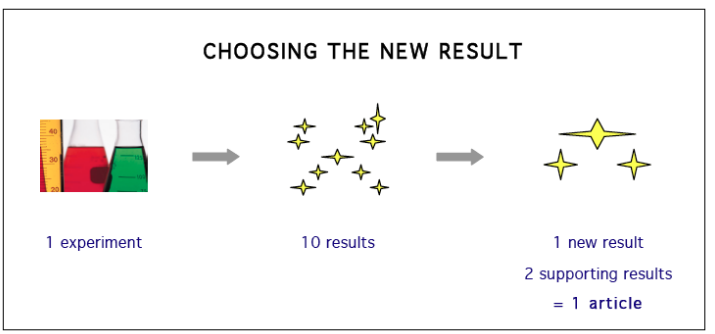
Petsko, GA (2008) Having an impact factor. Genome Biology 9: 107

A quick tip for doctoral students

Most universities require you to have published one or two articles before you can defend your thesis. Do not wait until the end of your thesis to start writing them! Even if you do not expect to obtain publishable results in the first year of your work, you could still write a review article based on the material you have collected for your literature review. You can also write educative articles that are accessible to the general public.

PREFACE

Publish or Perish. This old adage illustrates the importance of scientific communication; essential to research, it also represents a strategic sector for each country's competitiveness. An often-neglected topic, scientific communication is of vital importance, with new information technologies accelerating and profoundly changing how knowledge is disseminated. The necessity of optimally disseminating experts' findings has also become crucial to researchers, institutes and universities alike, which has prompted the recent advent of Impact Factors for the evaluation and financing of research, the goal being for scientific knowledge to be equally distributed to a very broad audience, especially to the media, entrepreneurs and sociopolitical players.



This handbook presents the "golden rules" for publishing scientific articles. In order to do away with major recurring errors, the author explains how to easily structure an article and offers support for the typical mistakes made by most scientists, tips on how to make the style more academic of more

general to fit your intended readership and, in the book's closing section, suggests new publishing techniques of the Internet age such as the micro-article, which allows researchers to focus their findings into a single innovative point. The major principles presented can be applied to a broad range of documents such as theses, industry reports, publicity texts, letters of intent, CVs/resumes, blogs and press releases, as all of these documents involve presenting information on advances, discoveries, innovations, or changes to our previous knowledge.

ACKNOWLEDGMENTS

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ABOUT THE AUTHOR

Eric Lichtfouse is Chief Editor of the journal Agronomy for Sustainable Development, which is ranking 4/79 in the category Agronomy and has been awarded the highest percent increase in citations in the field of Agricultural Sciences by Essential Science Indicators^{SM}. He is Chief Editor and founder of the journal Environmental Chemistry Letters, the book series Environmental Chemistry for a Sustainable World and Sustainable Agriculture Reviews. He has also founded the Association of Chemistry and the Environment. He has build innovative publication assistance services and is teaching scientific writing and communication in Europe and in the USA. To help scientists designing high impact articles he has invented educational tools such as the micro-article – described in this book - and speed writing sessions. He has organised and chaired the session 'Local assistance of scientists and institutes by editors' at the 11th Meeting of the European Association of Science Editors. Eric Lichtfouse has published highly cited research articles in the fields of environmental chemistry, isotope geochemistry, soil science and phytoremediation. Further details are available in ResearcherID, hal.archives-ouvertes and LinkedIn.

Chapter 1

GENERAL ADVICE

INTRODUCTION

This book can be used in two ways:

- By working through the material in the order listed in the Contents on page v;
- Starting with one of specific problems listed in Table III (p. 5).

Scientific Communication and Society

Publish or Perish

Although this Anglo-Saxon adage might seem a little harsh, it nevertheless has the virtue that it encapsulates the importance of scientific publishing, for not just for researchers but also leading-edge companies, research organizations and governments. There would be little or no science without scientific publishing. Unfortunately, in many countries there is often little training available in scientific writing and communication, which is surprising given how important it is to science. In my experience as a French researcher who has worked in several laboratories in France, Germany and the United States, I estimate that half of research results are either not published, or are rejected by journals because of the quality of the writing. In the following sections I describe the main problems encountered by authors.

Table II. Main problems in drafting articles and those most affected

TYPICAL DRAFTING DIFFICULTIES	
TYPE	THOSE AFFECTED
Form	All researchers
Substance	Young researchers
Cultural	Non-English speakers
Communication	All researchers
Education, dissemination	All researchers

In the course of my career as a journal editor I have corrected many thousands of articles and I see the same problems coming up again and again. Table II lists the most frequent problems.

Form and Substance

Slack Presentation Implies Slack Science

Form issues relate to how the article is presented; in particular the writing style and how the content is organised. Issues related to substance refer to the scientific value of the article, its novelty and the contribution that it makes to current knowledge. As the old adage suggests, problems with form and substance are rarely independent. Given that is *a priori* easier to improve the presentation of an article than it is to do the research, journal editors and experienced scientists consider poor presentation to be a strong indicator of mediocre research.

However, errors in both form and substance can easily be corrected, especially if you follow the instructions given in this book. For example, in the section on Novelty (p. 13) I explain how to handle the problem of an apparent lack of novelty in an article and the micro-article (p. 9) is a practical tool that authors can use to help them identify the focal point of their paper.

Cultural Differences

I systematically see poor writing that is due to cultural differences. Examples are meandering manuscripts that lack focus; they typically use long, convoluted sentences that only eventually get to the point. It is a typical mistake of authors from various cultures and is very often the reason why a

manuscript is rejected by reviewers. Cultural differences can be difficult to correct as the author has been immersed for many years in a particular educational environment. A section of the book is therefore dedicated to the typical problems seen in texts written by authors who are native in a foreign language – and their remedies (p. 6).

Lack of Communication

With very few exceptions, the articles that are submitted to the journals I edit do not do a good job of communicating their message. They do not clearly explain the background to the study or the general challenges. Alternatively, they fail to describe the problem to be solved or do not explain what is new in their results. Some authors misuse abbreviations in an attempt to make their writing even more obscure. In recent years I have seen new problems emerge that are due to the move from paper to the computer as the primary means of communication. This manifests in titles and abstracts that are not optimised to attract a high ranking by search engines, e.g. Google or Google Scholar. Such problems are typical of experienced researchers who are less familiar than their younger colleagues with electronic means of communication. This problem, and some solutions, is discussed in detail in the section on Communication that begins on page 18.

Lack of Education and Dissemination

Researchers are partly responsible for the gap between the research world and the general public. More than half of the articles submitted to my journals have no educational component. Very few researchers make the effort to make their work available to a wider public. This is typically because they write for their isolated community of laboratory colleagues. As a consequence I often advice in my lectures: ‘please do not write only for yourself’. In fact, after reading some of the articles submitted to my journals, I wonder if authors believe that education should be avoided because science is necessarily complex and obscure, even secret. Moreover, authors seem to assume that reviewers consider the educational aspects of their article to be self-evident. However, it is essential that the paper contains a clear explanation of the foundations of the study and a description of the implications and benefits of the research, not only to educate a wider audience but also to make it easier for

the specialist to read. Finally, I would like to remind authors that articles that educate their readers are cited more often. Some strategies that authors can use to increase the educative elements of their articles and improve dissemination are described in the section on Education and Dissemination that begins on page 24.

Strategies for Improvement

Know Thyself

This maxim from Socrates suggests that problem-solving requires greater self-knowledge. But the person that we know the least is often ourselves. This tendency is particularly exacerbated among researchers as their work means that they can find themselves isolated in a small scientific community. The researcher receives very little constructive criticism of their writing because research is carried out in a conservative environment where colleagues seek to manage relationships rather than explain frankly why the results of their peers are not new. This creates a particular style of writing that the wider public finds difficult to understand. Ultimately, the only really useful feedback comes when the article is assessed by anonymous assessors during the peer review process. Unfortunately, good journals have a very high rejection rate. For example, the rejection rate of one of my journals is about 80%. This can be painful for researchers who have invested considerable time in the preparation of their article and are convinced that it is excellent. Unfortunately, a frequent problem is that the author has not clearly highlighted the new finding and contribution of their research. Therefore, this book gathers together some simple solutions to the problems encountered by most authors, with special emphasis for authors whose native tongue is not English. The suggested solutions are deliberately short and to the point.

PROBLEMS AND SOLUTIONS

This section first presents some problems encountered by all authors and suggests some solutions. This is followed by a section that focusses particularly on the problems encountered by foreign speakers.

Problems Common to All Authors

Table III shows a list of typical problems found in scientific articles submitted to journals. Authors may find it useful to check through this list before submitting their article. A quick check that these problems do not appear in your article may avoid immediate rejection or worse, rejection several months later. This list distils the problems I have encountered in my career as an editor and the review of many thousands of scientific articles. Problems are ranked in descending order of appearance.

Table III. Main problems found in scientific articles

PROBLEM	SOLUTION	PAGE
Novelty not explained	Explain the newness, the difference that your results make to current knowledge	13
Does not conform to specified format	Respect instructions to the letter	33
Outside the scope of the journal	Select the right journal before submitting	30
Latinate style	Get to the point	6
Poor use of figures	Figures should be simple and communicate the newness of the result	12 58
Poor English	Hire a professional	7
Lack of education and dissemination	Explain the context, the challenges, the implication and the benefits for the wider public	19 26
Too many results or results lack focus	Remove any results that do not support the main conclusion	15 21
Results are not explained	Delete these results	21
Readers are confused, style is ambiguous, references are in the wrong place	Clearly distinguish between your results and those of earlier work	22 51 53 67
MU of AB*	Do not use abbreviations	44

*MU: misuse. AB: abbreviations.

Typical Problems for Native Speakers of Foreign Languages

Straight to the Point

Table IV shows the problems typically found in articles written by authors who are native speakers of a foreign language. These problems are particularly difficult to correct because they are cultural. Authors are imbued by their education and environment with a mode of expression that values diverse, colourful writing, full of detours and stylistic effects. Although it is an eloquent style, well-suited to writing Romanesque novels, it is not particularly adapted to the preparation of a research paper in English, where the priority is to communicate ideas quickly and accurately. In terms of substance, authors must make sure that they focus on a single new result, backed up by facts and arguments that converge to support it. As far as form is concerned, authors must use simple sentences consisting of a single verb in the form of a subject-verb-complement. Repetition is not a defect in English; it is most important to be understood. Authors should use 'I', 'we', 'our' or 'this study' in order to distinguish their findings from the work of others. It is easy for your reader to become confused when this is not made clear.

Table IV. Typical mistakes made by non-English natives

PITFALLS OF FOREIGN WRITERS	WRITING IN ENGLISH
Quantity is preferred to quality	Quality is preferred to quantity
Long, complex texts	Short, easy-to-read texts
Romance, detours, colour, stylistic effects	Concision, focus on a single main point
Too many results presented	One-three results that support the main finding
Results are not discussed	All results are explained
Irrelevant observations	Results converge around one main finding
Long sentences with many verbs	Short, simple sentences
Style is impersonal, vague, equivocal and in the third person.	Style is personal, precise and unambiguous: I…, we…, our findings…, this study…, here I show…
Orphan sentences	Well-organised paragraphs
No repetition	Repetition is not a weakness

A Tip for Non-English Native Speakers

Professionals such as American Journal Experts and Edanz (edanzediting.com) provide a quick and efficient service to correct grammatical errors and improve style. Other scientific proofreading services can be easily found on Google. A list of proofreading services is also available on the website of the European Association of Science Editors (ease.org.uk). Prices are generally very low compared to the cost of research.

WHEN SHOULD I START WRITING?

This section explains the best approach to take to ensure good-quality writing from the moment work begins.

Quality and Quantity of Results

The most common mistake made by researchers is to delay writing until after they have all their results. The young doctoral students often only begins writing their dissertation after two or three years of work. This is partly due the fact that it is more difficult to write than to carry out experiments and partly to the fact that the young researchers cannot see the potential novelty in their preliminary results. However, it is quite possible that these 'hidden' findings can be the subject of a pilot article before proceeding with other experiments.

Writing up results is an inseparable part of the overall research process. If you do not analyse your results at a very early stage, you risk overlooking potential new avenues for research, which could turn out to be far more innovative than your initial hypothesis. As far as results are concerned, young researchers must orient themselves towards quality rather than quantity.

Never Stop Writing

Long before the first experiments are carried out, preliminary steps such as the preparation of the research proposal, formulating a hypothesis, and

drawing up an experimental plan or a project programme can provide essential input to the final document (Figure 1).

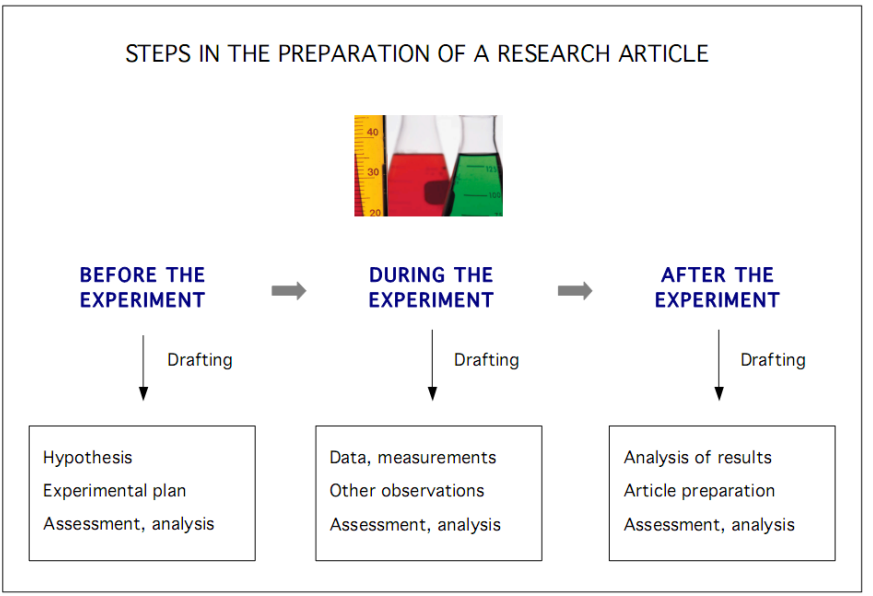

Figure 1. Main steps in the preparation of a scientific article.

These elements are crucial because they determine the novelty of the research and consequently form the essence of an article. Writing continues during the experiment or project, in the form of handwritten notes. Here, good-quality writing and presentation are important in the final drafting. Not only should the researcher record their planned measurements, but they should also note any other observations. Major discoveries are sometimes the result of unexpected phenomena. Finally, once the experiment is finished all the written information is gathered, analysed and synthesised to develop an article.

Analysis and Comparison

For optimal effectiveness, the young researchers must systematically analyse their hypothesis and results using all the means at their disposal. These include a comparison with results found in the literature, seminars, poster sessions, conferences, and discussions with supervisors, colleagues, scientists from other domains and non-scientists (see also p. 15). After more than twenty

years of research, I have noticed that informal events such as coffee breaks, lab seminars or discussions in external contexts, such as hiking, often give rise to very innovative ideas. This is understandable as informal settings promote the freedom of thought vital to innovation. Moreover, events such as the Gordon Research Conferences use this principle to bring together world experts in fun and casual surroundings where formal wear is strongly discouraged!

THE MICRO-ARTICLE

This section describes a tool I invented for the practical session of my writing course for doctoral students and researchers. The idea is to help the author to select a single innovative finding (Figure 2), which will be the focus of the article. In other words the micro-article is the thinking equivalent of chemical distillation.

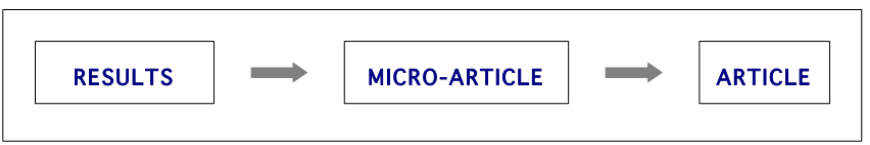

Figure 2. The micro-article helps the author to select a single new finding from among many heterogeneous results.

Identify the Main Finding

The hardest part of writing is analysing the results. The authors are faced with a huge amount of data and various observations from which they must select a single innovative finding and possibly one or two other results that confirm the first. This focus on a single result is essential because it is all your reader will remember. Researchers must weigh each result to identify its novelty, added value or contribution to current knowledge as these qualities define a research article. If your results confirm the hypothesis, the task will be easy enough. However, even if your results do not support the initial hypothesis, the experiment may still provide an unexpected innovation although it may be necessary to reformulate the article's hypothesis and background (see p. 35).

The framework for the micro-article is shown in Figure 3. This one-page document is a stepping-stone between a lab notebook filled with heterogeneous results and observations and the final article. Space is deliberately limited in order to focus on a single new result. The author can then weave the rest of the text around this main finding, which forms the heart of the article. The procedure for preparing the micro-article as follows:

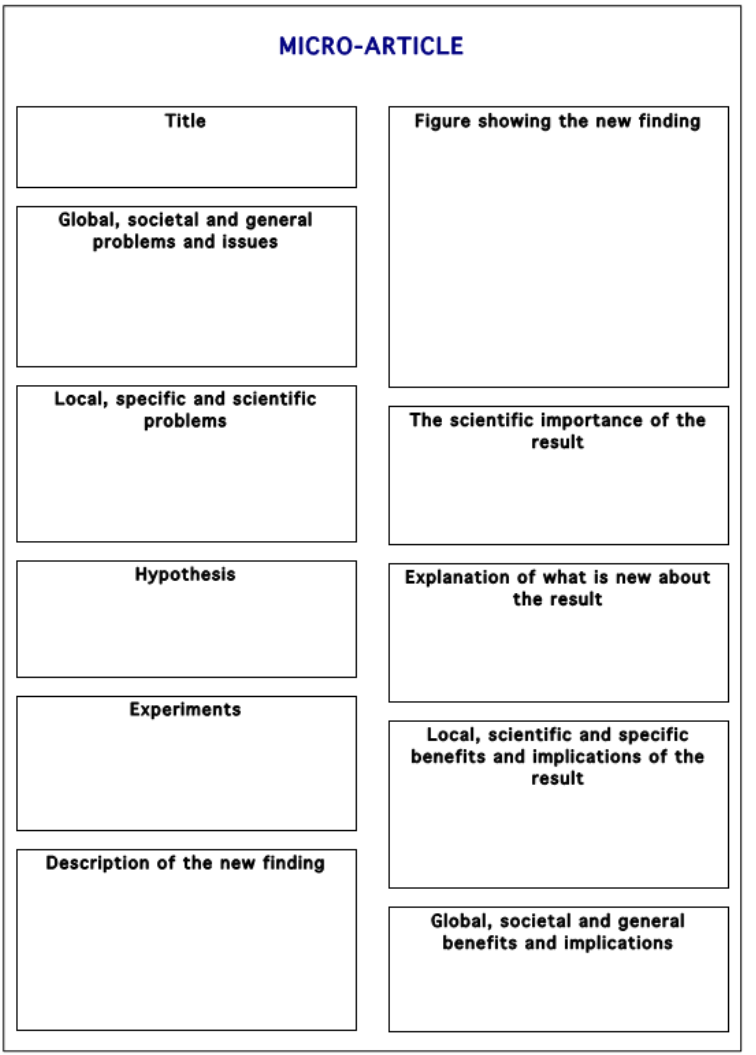

Figure 3. The micro-article. This tool enables the author to identify their results and to focus their article on one main finding.

Preparation of the Micro-Article

Title

Ideally the title is short, but understandable by a broad readership. It must contain a few high-impact keywords so that the article can easily be found by search engines. The best titles emphasise novelty, added value or what the article adds to current knowledge. Examples include: 'Novel...', 'Unexpected...', 'Evidence for...', 'Alternative...' (see also p. 49).

General Issues

Select some keywords to describe the societal and global issues covered by the article, the general challenges and problems to be solved. These words must, if possible, relate the topic to general societal issues. They must be understandable by a broad audience and enable the reader to quickly understand the key issues. They often highlight a problem in applied research. Examples include: climate change, global warming, soil pollution, cancer, diabetes, hunger, poverty, alternative fuels and economic crisis.

Specific Issues

Select a few other keywords to describe the local, scientific and specific issues the study addresses. These keywords should highlight the challenges, knowledge gaps, technological barriers and weaknesses in fundamental or applied research in the specific discipline in question. These keywords will have a smaller audience but should nevertheless be understood by scientists outside your domain. They constitute a transition between the broader issues and the hypothesis. Examples include: Cu adsorption, DNA, *Triticum aestivum*, antimalarial 3-hydroxypyridinone, social interdependance theory, land subsidence.

Hypothesis

Explain the hypothesis in one sentence. Examples: Soil cadmium should increase animal mortality. Pesticides should increase cancer rates.

Experiment

Describe the experiment and the method in a few words.

Description of the New Finding

Describe the main innovative finding. Example: 'We observed an increase of 24% in…'

Figure

Draw a simple figure showing the main result of the study. Figure 4 is an example.

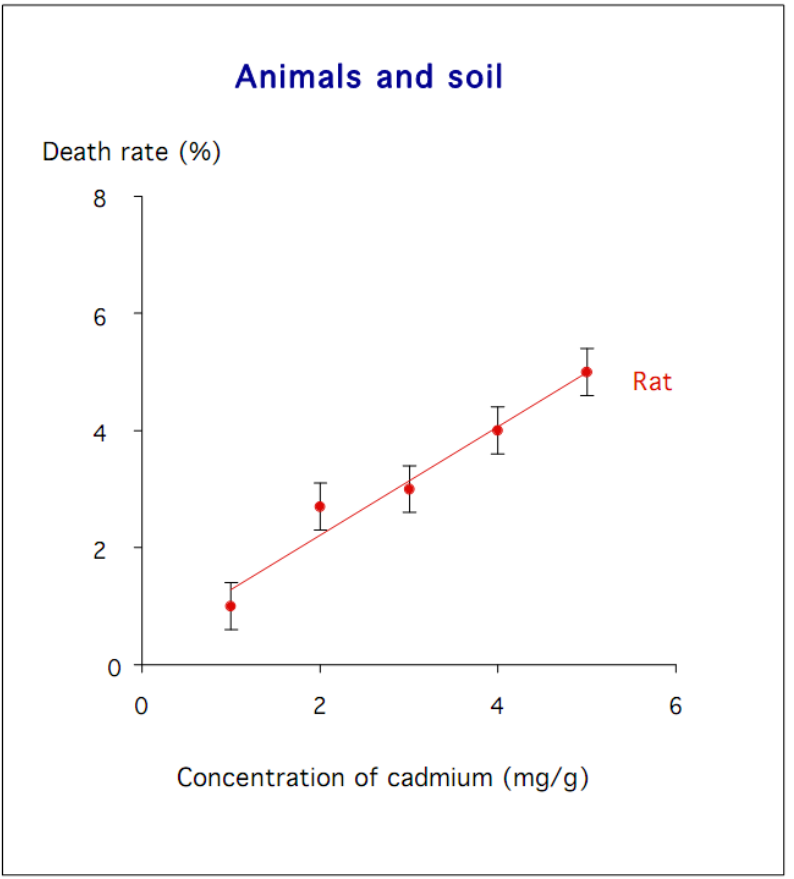

Figure 4. Sample figure for the micro-article. This figure must be designed to illustrate the main new finding of the experiment.

Scientific Importance

Interpret the scientific importance of the main finding. Example: 'The increase in rat mortality demonstrated the toxicity of soil contaminated by cadmium.'

Explain What Is New

Explain the novelty, difference, or the contribution of the result to existing knowledge in the specific field. Example: 'Our results show for the first time the toxicity of soil contaminated by cadmium on rats.'

Explain the Local, Scientific and Specific Benefits and Implications

Explain the specific implications of the result. Example: 'Our results highlight the poisoning of animals raised on soils contaminated by cadmium.'

Explain the Global, Societal and General Benefits and Implications

Explain the general implications of the result. Example: 'Our results show that soils contaminated by cadmium may pollute ecosystems and the food chain. We therefore recommend that food crops should not be grown in soil polluted by cadmium and that all polluted soil should be decontaminated.'

NOVELTY

The primary objective of a research article is to communicate new information quickly. Therefore its two essential qualities are novelty and the ability to communicate results. Although this definition may seem obvious, in the course of my work as an editor I have observed that not only do more than half of the articles I see fail to communicate their results, almost none of them clearly explain their novelty! This section first describes the different forms that novelty can take. It then outlines some strategies to help you to identify your principal finding – even when it appears there isn't one. Finally, it offers some tips on how to structure your article in order to ensure that your main finding is clearly demonstrated.

Forms of Novelty

Expect the Unexpected

Table V shows that novelty can take many different forms. In the course of everyday research, novelty often does not appear where it is expected. Even if the hypothesis is not supported by the results it is possible that the experiment provides an unexpected innovation.

Table V. Examples of forms of novelty

FORMS OF NOVELTY	
BASIC RESEARCH	APPLIED RESEARCH
A new mechanism	A new invention
A new concept	A new technology
A theoretical advance	An improved technique
A new interpretation	A practical advance
The first observation	New methodology
The first exploration	An improved method

For example, it could lead to the development of a new experimental method or a significant improvement to an existing method. In which case the author may find an audience in a journal focused on methodology. Similarly, the study may reveal a new concept, highlight a new mechanism or identify a new species (see Reformulation of the hypothesis p. 35).

Lack of Novelty

Reviewers cannot assess an article that does not show any new findings.

A research article must demonstrate an advance on current knowledge. However, most authors do not explain what is original about their work. From an editor's point of view, there are two reasons for this:

- The results are in fact not new. Although the author knows this, they still attempt to have the work published. This is a serious error, which is unfortunately quite common. Not only will the article be rejected during the peer review process, but also the author will lose credibility in the eyes of their peers. Worldwide specialist communities are often small and tightly-knit, everyone knows everyone else. In this case, it is better not to even attempt to have the article published; it is simply wasted time.
- The second reason is more common. In this case the authors miss the fact that they must explain the novelty of their results. This particularly applies to young researchers who find it difficult to know which result to highlight and tend to provide as many results as possible, as they did in their thesis. Rather than identify one main finding and explain its novelty, they aim to demonstrate how much

work they have done. Consequently the new result is hidden in a large amount of data. On the other hand senior researchers do not see the need to explain the novelty of their results because it is obvious to them from the findings. However, the purpose of a research article is to demonstrate an advance on knowledge. When this is not clear, it is impossible for reviewers to make an assessment or take a decision on the article. Although editors cannot ask reviewers to evaluate an article that does not clearly demonstrate an advance, some do slip through the net. This usually happens because senior reviewers and editors work in the same domain as the author, and the novelty of an article also seems obvious to them! Consequently, peer review reports rarely mention that the novelty of the article is not clear.

Choose One Main Finding

Straight to the Point

The new advance is identified when the results of the experiment are analysed. It is at this stage that the author should select a single, innovative finding. Remember that your reader will retain, on average, only one point from your article. This critical step is far from obvious, especially if the novelty is not where you expected. Young researchers will find it difficult to identify novelty because they have a limited knowledge of the field. Paradoxically, senior researchers who are particularly specialised in their domain may miss the potential application of an innovation to another discipline.

Some techniques to identify innovative results are illustrated in Figure 5. First of all, the researchers compare their results and their meaning to the initial hypothesis, which is then validated or not. They can also carry out a supplementary review of the literature to see if they may have identified a new trend. It is often useful for authors to discuss their findings with colleagues and to present their results at internal seminars or international conferences. When taking part in these activities, authors should pay particular attention to any questions and comments, especially from specialists in the field, as these can confirm or invalidate the supposed novelty. Sometimes colleagues can identify new points that authors did not notice or expect due to their partial knowledge of the literature. This can also happen during the peer review process.

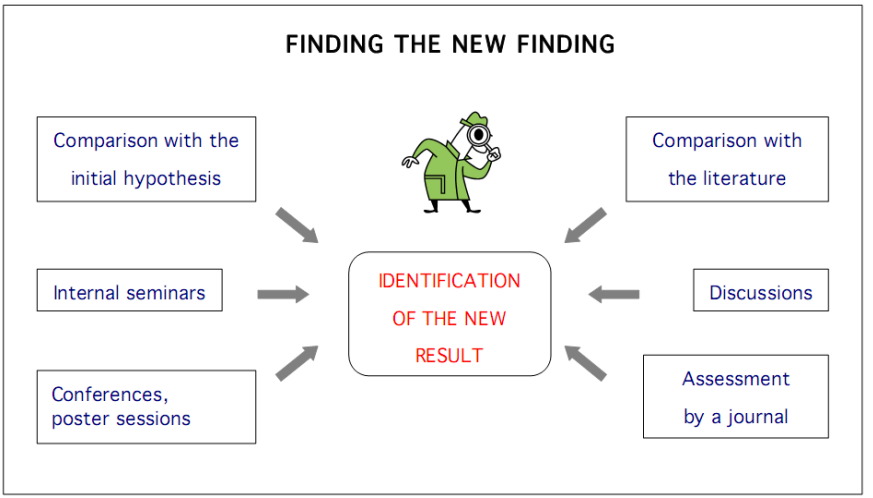

Figure 5. Techniques to identify and select the main point of an article.

Explaining Novelty

At Least Three Blows Are Needed to Hammer in a Nail

Your manuscript is built around one new result. Therefore, before you start writing you must have already identified what is new about your work. To ensure that your reader remembers your new result it must be explained in detail in three sections: the abstract, the results and discussion, and the conclusion. The article will have even more impact if you can highlight your new discovery in the title. You are also more likely to impress an editor if you can explain your new result in a few sentences in the covering letter or email that accompanies the submitted article. This is not a trivial point: by demonstrating that you have the courage to take risks, an essential element of research, you will create a good first impression.

The demonstration of the novelty of your findings should not be limited to a simple assertion. The reader must be able to fully grasp the contribution of your work to existing knowledge (Figure 6). One effective way to demonstrate novelty is to use a counterweight technique. This takes the form of a comparison between existing knowledge and the claimed new discovery. Starting with the abstract, the author must explicitly relate the specific challenges and knowledge gaps to the novelty of the results.

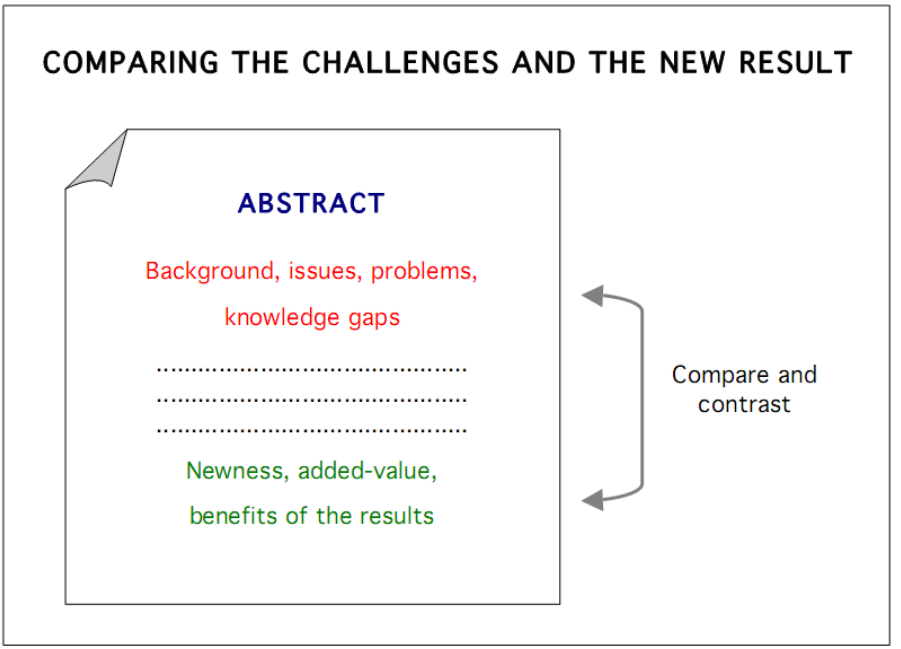

Figure 6. In the Abstract, the author must compare and contrast known issues with the new results. The same approach applies to the rest of the article. The issues described in the Introduction are compared to the new results that are explained in the Results and Discussion and the Conclusion.

Similarly, the novelty described in the results and discussion and the conclusion should relate to the issues and problems described in the introduction. In the results and discussion, the author must first describe and interpret their results, then explain how they contribute to existing knowledge. This explanation should be supported by bibliographic references. More generally, the entire article must demonstrate several, well thought-out contrasts between the known and the new. This comparison between problem and solution affects the order in which the sections are written. The author cannot develop a well-balanced introduction unless the new result and its implications are clearly identified in the results and discussion.

COMMUNICATION

Researchers often forget that a research article is above all a communication tool and its purpose is to transfer scientific information from one individual to other individuals. Effective communication depends on the contents of the article, the potential or target audience and technology used to transfer the information. This section first describes the impact that the Internet and information technology has had on the way bibliographic research is carried out and how this affects the contents of an article. It then outlines some new problems resulting from the use of information technology to prepare articles and explains why it is important to focus on only the most important points. Finally, it provides some tips on how to structure an article using a problem-solution form.

Impact of the Internet and Information Technology

Since 1990, the Internet and information technologies have profoundly changed the way science is carried out. There have been major changes to the practice and direction of research, the way bibliographic research is carried out and how results are communicated. One notable consequence of the ever-increasing rate of publication is that researchers tend to favour short experiments that can rapidly deliver publishable results.

Bibliographic Research

Before the advent of the Internet, researchers would go to a library and consult specialised journals to carry out bibliographic research (Table VI). Nowadays, they use their own computer to consult publications directly.

The Internet has made it possible to carry out a keyword search using search engines such as Google Scholar or Google, or databases such as PubMed, the Chemical Abstracts Service or the Web of Science. This has significantly changed the way researchers select their material as a keyword search can deliver millions of references in less than a second. Hyperlinks also play a significant role in improving the visibility of articles (see p. 67).

Impact of the Internet on Titles and Abstracts

Paradoxically, while before the researcher had immediate access to the entire paper version of the article, there are now two steps to downloading a

full article. The first step is to select a set of relevant titles from the millions provided by the search engine. The second step is to skim through the abstracts and select four or five articles to download and read in full. This two-stage selection process means that the title and the abstract play a key role in making the article visible to the reader as they are always freely available to all users, while access to the full article must often be paid for. Therefore, the following points must be kept in mind in the preparation of an article:

Table VI. Effects of the Internet on bibliographic research

BIBLIOGRAPHIC RESEARCH	
BEFORE THE INTERNET	NOW
In libraries	Directly by computer
Access to only a few journals	Access to millions of articles
The entire article can be read at once	There are two steps to accessing an article: - The title and abstract are freely available - Access to the full article is restricted

- The title must be accessible to a broad readership. It must contain fairly general keywords that highlight the importance of the topic. Keywords should, if possible, be placed at the beginning of the title because of the ranking methods used by search engines (see p. 49).
- The abstract must not be too short. Nor should it simply present the results. It must summarise the entire article including the context, the general and specific issues and the hypothesis in three or four sentences, and the experiment in a maximum of four sentences. It must also in five or six sentences include up to three main findings, describe what is new about them and explain their implications and benefits (see p. 52).

The Impact of Information Technology on Document Preparation

An amazing effect of Internet
Subject: Paper submitted to *Agronomie*
To: agronomie@avignon.inra.fr
Dear Éric Lichtfouse,
Kindly find attached file (MS Word) of my paper entitled […] for publication in *Plant Science*. I hope the paper meets the laid down criteria of publication. Kindly acknowledge receipt.
Best regards

As Chief Editor of the journal Agronomie in 2004, I received this e-mail message including the submission of a manuscript. What a surprise to read that whereas the name of my journal – Agronomie – was correct in the Subjet of the message, the name of another journal – Plant Science – appeared in the body text of the message! Did the author submit the same paper at the same time to Plant Science, and then made a copypaste of the message? Does the author even read his messages?

Before 1990 and the widespread use of computers, writing text, whether by hand or typewriter was slow (Table VII). Proofreading was particularly laborious. This meant that the author had to think carefully about the content and organisation of their article before beginning writing. Similarly, illustrations were prepared in advance as drawing figures by hand was very slow. Although there is no doubt that computers have made the process of writing and the design of figures vastly easily they have also highlighted the shortcomings of writers. As an editor, I see increasing numbers of articles that are submitted with mistakes that were previously unimaginable.

First, rather than carefully crafting well-structured paragraphs, some authors have adopted a telegraphic, disjointed style that seems to be the result of the ability to easily copy and paste blocks of text. It is not uncommon to receive submissions with a large number of single sentences. Secondly, as software has become available that makes it easy to create figures major flaws have appeared, such as too many graphs and very little text. This is a mistake typical of young researchers who present all their data in multiple figures rather than designing a single figure that is focused on the main finding. Finally, and paradoxically, despite the fact that computers have made it easy to manipulate figures, authors no longer take care of the basics, such as ensuring that their figures clearly communicate the necessary information.

Table VII. Effect of computer tools on writing

WRITING AND INFORMATION TECHNOLOGY	
BEFORE COMPUTERS	NOW
Slow, by hand	Fast, by computer
Structured, concise, focussed writing	Disorganised, fragmented writing that is difficult to read
Well-designed figures	Too many figures, poor design

Focus

Too Much Information Kills Information

Many authors unconsciously obscure the innovative aspect of their work. A typical example is a 'quantity over quality' strategy that consists of listing as many results as possible in order to demonstrate how much work they have done, rather than weighing the importance and meaning of their data (Figure 7). However, this strategy that is typical of graduate students and young researchers means that the main finding is hidden amongst a dozen other results and observations that are more or less relevant. Remember that the average reader will only retain a maximum of one main point from an article and that an article does not serve the same purpose as a thesis. Articles are short and focus on one main finding, whereas a thesis often contains all the results obtained during a PhD. Moreover, theses often contain results that are not suitable for publication but which may provide new avenues for investigation. In an article, too many incoherent results mean that the task of the reviewer and the editor becomes very difficult, if not impossible.

To overcome this problem, authors must carefully select which results they are going to publish when the experimental data is analysed.

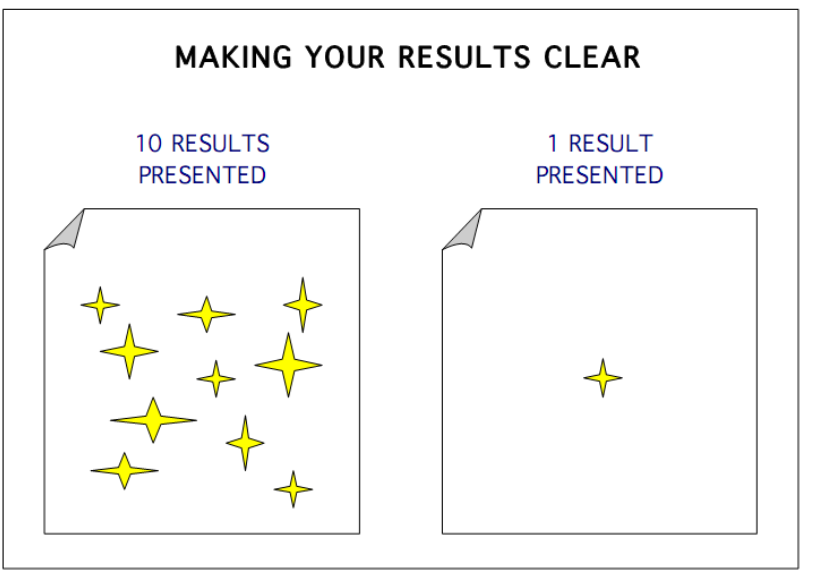

Figure 7. Too many results hides the new result.

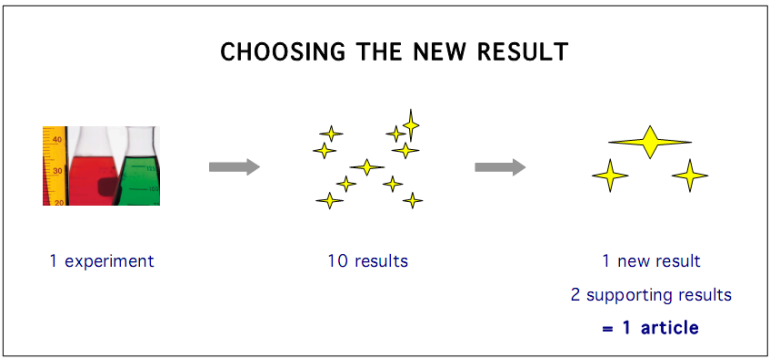

Figure 8. When analysing the results of an experiment, the author selects one innovative result and two supporting results to form the basis of the article. A supporting result reinforces the interpretation of the new result. Other results are not published or may be published in another article if they merit it.

Once the new discovery has been identified, they must sort the rest of the experimental data into three categories (Figure 8):

- Data that clearly demonstrates the main finding. This data is included in the article. The author uses it to draw up one or two well-designed figures that form the central reference point for the text.
- Secondary data that reinforces or confirms the new result. This data may appear in the article, but only in the text and probably in the form of tables rather than figures. The author must limit this information to the identification of a maximum of two trends. Secondary data does not usually appear in the abstract.
- Irrelevant data. This data does not support the new finding. It should not appear in the article as it risks confusing the reader. In cases where experiments result in several new findings such as a technological innovation, the discovery of new species or a conceptual advance, it is best to write several short papers; provided of course that all the new discoveries can be solidly supported by the data.

The Problem-Solution Structure

A major weakness, especially among young researchers, is writing that is disjointed, fragmented and ambiguous. The author prepares a diverse mixture

of general comments, results, specific issues, the results of the literature review and casual observations. The general challenges and the specific problem to be solved are often sketchily described, rarely correspond to the results and sometimes do not appear at all, giving the impression that the author thought the justification for their work was self-evident.

A simple way to overcome this problem is to structure the text in problem-solution form (Figure 9). In practice this consists of aligning the challenges, issues and the hypothesis - the problem - with the principal finding, its meaning and its implications: the solution. In other words, the solution must be clearly compared and contrasted to the problem. While this might seem simplistic to the experienced author, this structure makes the article much easier for the reader to understand. At the same time, the author must describe the problem and the solution at several strategic locations in the article to ensure that they are remembered by the reader. They must also remove any arguments that do not directly support the main finding. Finally, they must adopt a personal style such as 'I', 'we', 'our results', 'here', 'in this study', or 'our findings imply that', to avoid any confusion between the interpretation and implications of their own results and the results of previous work.

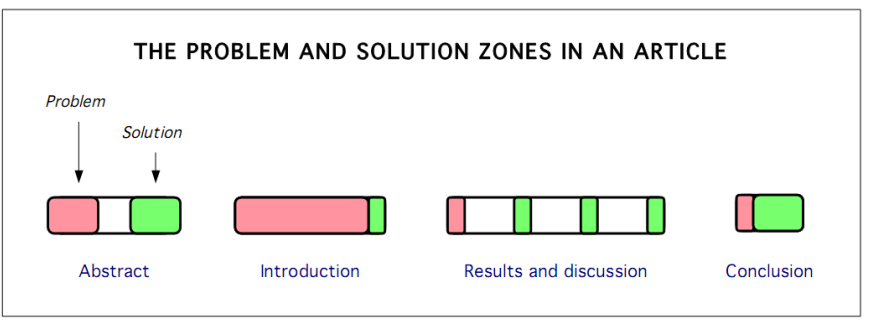

Figure 9. Article structure in the form of problem (pink) and solution (green). The problem and the solution are compared and contrasted. The Abstract begins with three or four sentences that summarise the problem: the general issues and the specific challenges. The Introduction begins by discussing these points in detail and ends with the hypothesis (the potential solution), which must correspond to the problem initially described. The problem is briefly recapped in two or three sentences at the beginning of the Results and Discussion. In this section, sub-sections describe individual results and end with an analysis of the meaning, novelty and benefits of the result which must clearly correspond to the problem. These elements are repeated at the end of the Abstract. They are also repeated at the end of the Conclusion, which begins with a brief review of the problem to be solved in order to highlight the added-value of the results.

Tell a Story

You Tell a Fine Tale!

The following tips are intended for senior researchers who have mastered the art of good writing. ‘This is a good story’ is a rarely-heard commendation from Anglophone reviewers in response to excellent articles. The use of the word ‘story’ is not at all trivial; it underlines the fact that top-quality articles have something extra.

They have succeeded in the supremely difficult task of telling a story while remaining scientifically rigorous. Senior researchers who have overcome straight forward problems such as lack of communication and novelty can further improve their writing by seeking to tell a story. This is a particularly difficult exercise for native speakers of foreign languages because over-elaborate writing is one of their major difficulties – authors must take care to use figures of speech sparingly. Here are two story-telling techniques:

- Amplify the contrast between the problem and solution. Specifically, this means the contrast between the context, issues, stumbling blocks and knowledge gaps and the main finding, its meaning, what is new about it and its implications;
- Another way to capture the reader's attention is to introduce the unexpected, ‘surprisingly…’ or ‘unexpectedly…’ for example. This approach is particularly effective when the main finding is not consistent with an established concept or when it provides a new explanation for a phenomenon.

EDUCATION AND DISSEMINATION

This section first explains why researchers must write articles that educate and can be widely understood, even if it is only to reach a broader audience or secure a new job. Then, it investigates why researchers find it difficult to see the educational shortcomings of their writing. Finally, it suggests some ways to introduce educational elements into the various sections of your article.

Audience

Do Not Write for Your Lab Colleagues!

Researchers who think that their article will only be read by the handful of scientists who work in their field are making a big mistake for several reasons. First, leading-edge research happens at the interfaces between disciplines. Therefore, it is likely that the reader who cites your paper will be working in another domain. This person is also likely to be a young researcher who needs to clearly understand the foundations and issues related to your work. I estimate that over 70% of the articles I see lack this element of education and dissemination. In general, most authors write as if their subject matter is obvious to the reader. However, a research article is a means of communication. Articles that do not communicate their message to a wide audience are not read and therefore not cited. Some authors seem to believe that education is not part of 'research' and that it is not their job to educate in a 'research' article. Finally, some researchers seem to believe that their work will be less well regarded by their peers if they include educational aspects. Here again the author is mistaken. Not only is an educative article accessible to the widest possible audience, it is also a more enjoyable read for specialists. Research articles should be understood not only by experts but also, at least partially, by new students, journalists, industrialists and the general public (Figure 10).

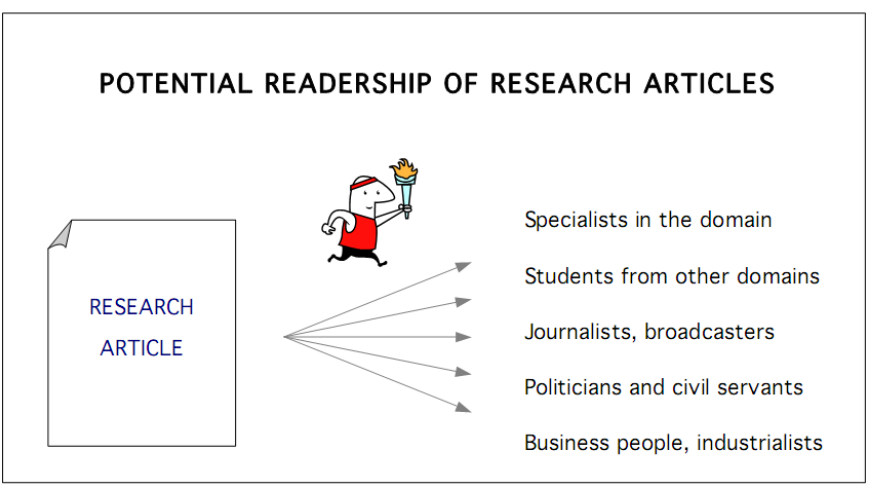

Figure 10. A research article should aim to educate and be accessible to a broad audience.

Employment and Careers

It is in a doctoral student's best interests to make their article educational because it may be read by a potential employer who is very likely working in another scientific field or a completely different sector. If the potential employer does not immediately understand your work, they will very likely move on to another candidate rather than ask you for an explanation. Experienced researchers should also include an element of education in their work. Project funding - whether public or private - depends on an ability to clearly explain the fundamental, societal or applied value of the anticipated results. Moreover, research projects are often selected by a jury composed not only of scientists working in a similar field, but also by socio-political actors. It is important to be able to convince everyone. Finally, the same argument applies to the assessment of researchers' careers, which is often done by a jury whose members are specialised in very different fields.

How to Identify a Lack of Educational Elements

Lack of Feedback

It is difficult for the author working alone to identify a lack of educational elements in their work. Researchers rarely ask their colleagues to take a look at their work before they submit an article and therefore lack any external perspective. The typical researcher acts more like a mole – silently digging their hole – than a cicada that constantly communicates with its environment. Even if the author does have their article corrected, it will probably be by colleagues working in the same field. These specialists are also unable to spot a lack of educational elements because they seem as obvious to them as they do the author. Nor do reviewers notice the problem – for the same reason. Ultimately, the only person likely to notice a lack of educational elements is the journal editor who usually has a broader and less specialised knowledge of a particular scientific domain.

External Proofreading

In order to identify a lack of educational elements, the author must have their article read by several external readers, particularly other scientists and people representative of a wider readership. The questions these individuals ask often reveal areas where improvements can be made to the clarity and understanding of the article.

Educational Areas of the Article

Figure 11 shows the main areas where the article must educate and be understandable by a wider public. These are:

- The beginning of the abstract, in the general description of the issues.
- The end of the abstract, in the explanation of the benefits and implications of the results.
- The introduction, where the context and issues are explained.
- The method section where the experiment is described in sufficient detail for it to be replicated.
- The results and discussion and the conclusion, which should explain the added-value of the result and its general implications and benefits.

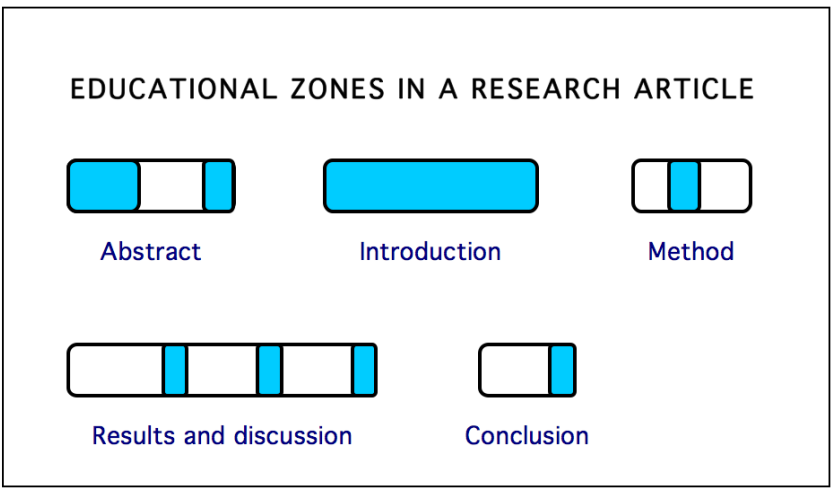

Figure 11. Areas of the article which should contain educational elements and be accessible to a wider public.

Title

In the age of the Internet the title of an article is of utmost importance as bibliographic searches consist of typing a few keywords into a search engine. The Internet user then has the challenge of selecting a few titles from the millions of results. Therefore the title of the article must not only reflect the new finding but also be accessible to a wide audience. For example, if the article is about the influence of greenhouse gas emissions on climate, words

that can be understood by the general public such as ‘greenhouse gases’ and ‘climate change’ should appear in the title. Authors also need to provide keywords that are related to the topic and are understandable by the general public. They should first list some keywords that identify the general scope of the topic and the main finding and then seek an independent opinion. Hopefully, the end result is one or two keywords that can be included in the title.

Abstract

Virtually all authors fail to educate their readers at two specific points in the abstract. First, it should begin with an explanation of the background, challenges and value of the proposed work in terms that are understandable not only by specialists but also by a wider public. The second place where authors typically fail to educate their readers is at the end of the abstract which must highlight the meaning, implications, potential benefits and the known or potential value of the main finding for both science and society. If these elements are missing or if the explanation is obscure or too specialised, the article will not be read. Remember that the title and the abstract are the only parts of the article freely available on the Internet. The abstract must therefore accurately reflect the entire article and contain much more information than has previously been the case.

Introduction

The introduction plays a large part in educating the reader. Often researchers are trying to elucidate a very specific or obscure mechanism in an overall process that can be more readily understood. Here, the author can improve their writing in three ways (see also p. 55):

- The text must lead the reader from the general to the specific; from global challenges and problems to specific or local issues (Figure 12).
- It must first describe societal and industrial challenges, then scientific issues. The description is supported by references to earlier work - review articles, books or chapters - which the reader can consult to find out more.
- The author must define any scientific terminology in ways that can be understood by the general public. For example, if the article is about greenhouse gas emissions and climate change, the author must clearly explain what the greenhouse effect is and why certain gases produce a greenhouse effect.

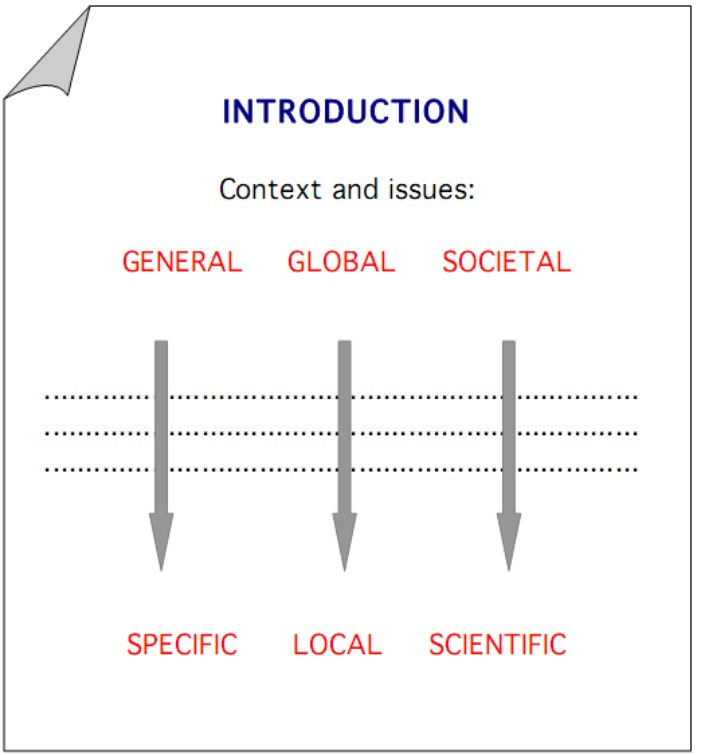

Figure 12. Structure of the introduction. The introduction must lead the reader from general issues to specific problems.

Method

In the method the author is not limited to describing the experiment as a bulleted list – as is often the case. The method should provide sufficient information so that the novice reader can easily understand the method used and potentially replicate the experiment. This section can also be used to justify the decision to use a particular method or technique. The contents of this section are supported by references to articles describing methodologies.

Results and Discussion, Conclusion

A Roundtrip from the General to the Specific

Authors often forget that the results and discussion must explain the meaning, consequences, implications and benefits (actual or potential) of their results – whether in fundamental, applied, scientific or societal terms. The

initial discussion should be very specific. Then the author must gradually return the reader to the broader implications of their results in terms that are understandable by a wider audience: effectively the reverse of the introduction. The conclusion must also briefly describe the overall implications of the main finding. A well-written article requires this roundtrip from the general to the specific and back again.

THEMES

This section discusses the fact that half of all articles sent to journals are outside their scope, resulting in a significant waste of time for the author. It then explains the difference between a cosmetic article and a reformulated article. Finally, it advises authors to carefully study the specific themes of a journal before submitting an article.

Article Submission

Stick to the Subject

Although scientific journals take care to publish their themes for the benefit of potential authors, the vast majority of authors do not appear to read them. For example, the general theme of my journal 'Agronomy for Sustainable Development' is agronomy, much like the eighty other journals categorised under 'Agronomy' in 'Journal Citation Reports'.

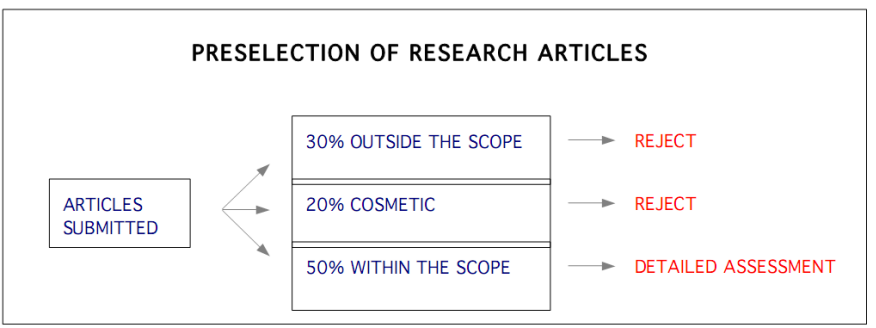

Figure 13. Pre-selection of articles according to the extent to which they correspond to the themes of the journal.

However, the journal publishes articles on the very detailed and specific topics of agroecology and sustainable development, which are specified on its website. Despite this, although 100% of articles submitted are on the general topic of agronomy, 30% do not correspond at all to the journal's specific topics, 20% are cosmetic (they appear to correspond but careful reading reveals that they fall outside the journal's scope) and only 50% do in fact fall within the specific themes of agro-ecology and sustainable development (Figure 13).

Articles Outside the Scope of the Journal

It is clear that 30% of authors have not read the Aims and Scope of our journal. They have nevertheless noted that the journal is about agronomy and has a Journal Citation Reports classification. These authors frequently have not applied the article format specified in the Instructions for Authors. This strongly suggests to an editor that the article has already been submitted to – and rejected by – another journal. It will therefore be rejected by the pre-selection committee. Such articles waste the time of both the author and the publisher. Unfortunately, the proportion of such articles is increasing as computers and the Internet make writing and communication relatively easy. To overcome this problem, the editors of reputable journals have established tougher screening criteria so that only the best-quality articles are sent for review.

Cosmetic Articles

In this case, the researcher's work is within the general scope of the journal, but outside the scope of its specific topics. An example would be a study that is focused on optimizing crop yields, but that demonstrates no environmental benefit. Once the work is completed, the researcher decides they want to publish in our journal, reads the specific themes and realises that their results are not appropriate. However, the journal has a high impact factor. So they make cosmetic changes to the text in order that the background, challenges and meaning of the results correspond to the specific themes of the journal. These cosmetic changes do not usually escape the notice of the pre-selection committee who will reject such submissions, particularly if the article is otherwise of dubious quality.

However, it should be noted that the boundary between a purely cosmetic article and a reformulated article can be blurred. In a reformulated article the background, challenges and hypothesis have been re-worked from those that were set at the beginning of the study (see p. 35). In this case it is possible that although the author initially devised an experiment that was entirely outside the scope of the journal, the results obtained are in fact well-suited to the journal's specific topics. In experiments that involve the measurement of many parameters, careful observation may reveal new mechanisms. In this case it is entirely acceptable for authors to rewrite the background and the hypothesis of the article to correspond to a journal's specific themes. What primarily distinguishes the reformulated article from the cosmetic article is the correspondence between the article's main finding and the specific topics of the journal. In the case of the reformulated article the results and their significance dovetail with the specific themes of the journal – this is not in the case for cosmetic articles.

Articles within the Specific Scope of the Journal

Authors of these articles have carried out an experiment designed to solve a problem that falls within the scope of the journal. The authors have carefully read the specific themes of the journal, either when the experimental phase is complete, or before they begin work. These articles will not be rejected provided that they meet the journal's quality criteria, namely they report a new finding, the presentation is perfect and they are written in excellent English. These articles are sent for peer review. In conclusion, authors must pay close attention to the specific themes of journals. This exercise should ideally be carried out before work begins, particularly for young researchers when they start their initial bibliographic research. An analysis of specific journal themes provides a quick overview of the various trends in a scientific field. Authors must take care to submit their article to a journal whose specific themes relate to the results obtained, the discovery, the main finding or the innovation. If this is not the case, they must select a more appropriate journal.

INSTRUCTIONS FOR AUTHORS

This section explains why the instructions that are provided for authors must be rigorously applied before submitting an article.

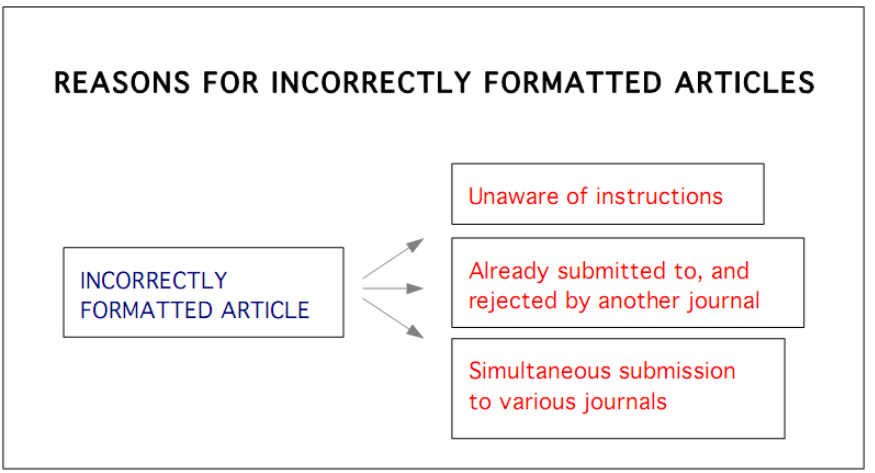

Figure 14. Reasons for a failure to apply the Instructions for Authors.

Every scientific journal publishes a list of Instructions for Authors in its first annual issue or on its website. However, more than 50% of articles submitted to the journals I publish do not rigorously follow these instructions. Over 30% do not respect them at all. There are three potential reasons for this (Figure 14):

- In the first case, the author consciously ignores the instructions, thinking that they can be applied if the article is accepted.
- In the second case, the author submits an article that has already been rejected by another journal, without changing the format to match that of the new journal. This behaviour is very common.
- In the third case, the author submits the article simultaneously to several journals. This is fortunately a rare phenomenon but has been made easier by the Internet.

The author probably thinks that these strategies will save them time. This is a big mistake for the following reasons.

Slack Presentation Equals Slack Science

Editors are immediately suspicious of an article that does not comply with the author's instructions. An article that is not in the correct format instantly attracts the attention of both the editor and the editorial board. A classic example is the failure to follow the correct format for references or section headings. These failings strongly suggest that the article has already been submitted to, and rejected by, another journal. Moreover, publishers and top-flight scientists firmly believe that if an author is not able to apply some simple formatting instructions, then their science is probably equally slack. By way of an example, here is an extract from a reviewer's report:

> First, it is really irritating to read a submitted manuscript which has not been carefully prepared and finished. The paper has a number of formatting errors that are very simple to correct and it is just slack by the author. I would tend to reject the paper just based on this condition – that Dr. [XX] is showing little respect for her peers time by asking them to read a manuscript which is not carefully prepared. This includes a reference list full of errors…

Moreover, an article that does not follow the correct format wastes the time of the ten or so people involved in the review and production of an article. Failure to follow the correct format manifests as a problem at various stages in the publication process, resulting in multiple requests for the article to be corrected.

This usually causes publication to be delayed by several weeks or even months. The author is usually upset by this delay – for which they are entirely responsible! Authors should note that editors are not particularly inclined to spend time correcting articles that are not in the correct format at the expense of other articles that meet the journal's requirements.

Authors are usually unaware of the economic constraints that determine the format of articles. For example, most journals have a limited number of pages per year; if this number is exceeded the publisher must pay a hefty sum for each additional page. This is why most journals limit the number of pages per article. An article that exceeds the page limit therefore represents a potential threat to the economic viability of the journal.

Finally, the editor or the pre-selection committee may decide to reject an article that is not in the correct format rather than ask the author to correct it, simply because it is an additional task in a management process that is often very demanding (Figure 15).

Editors are also reluctant to ask authors to correctly format an article as it risks giving the impression that the article is otherwise acceptable. The editor is unlikely to risk the displeasure of the author should the article be subsequently rejected for scientific reasons.

Figure 15. Articles that do not rigorously respect the Instructions for Authors are rejected.

Paradoxically, while authors increasingly complain about timely reviews and long delays in publication, they often cause delays themselves by not complying with instructions. It is therefore imperative for authors to check the final version of their article very carefully.

REFORMULATION OF THE HYPOTHESIS

> Often an experiment wants to tell you more than what you first expected, and often what it tells you is more interesting than what you first expected.
>
> *Jean-Marie Lehn*

This section explores the complexities of innovation. It explains, in particular, that novelty is not necessarily predictable and provides help for novice writers when their experiment does not deliver the expected results.

Unexpected Results

Help! My Experiment Isn't Working

This feeling, shared by all young researchers when an experiment doesn't go as planned reflects a lack of knowledge about research, particularly the winding paths that lead to new discoveries. This is due to the lack of proper teaching in universities and engineering schools. Young researchers have just completed a stage in their career where learning, rather than innovation was the main activity. They carry out their initial experiments, then note with bitterness that the expected trends were not observed. What they don't know is

that it is quite possible that they have discovered something new, just not what they expected. In the analysis of their results, a secondary parameter may show a curious behaviour. If this turns out to be a new trend, the hypothesis can be reformulated for the purposes of an article. To better understand this process, let's take a hypothetical example (Figure 16).

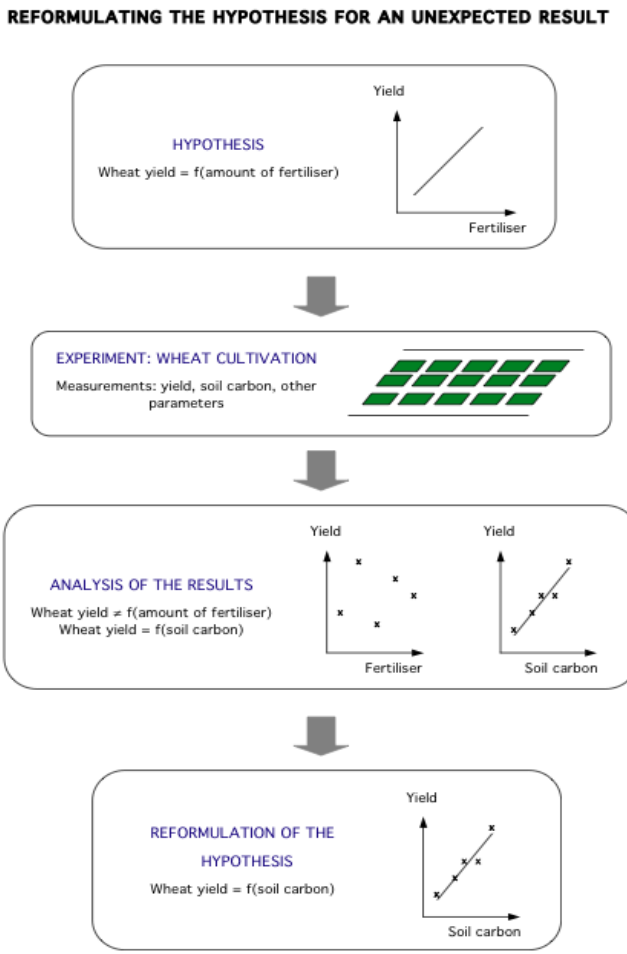

Figure 16. How to reformulate a hypothesis following unexpected results. In this case, the results of an experiment do not confirm the initial hypothesis. Nevertheless, a related result demonstrates a new, but unexpected trend. The author must then reformulate the article's context, issues and the hypothesis to correspond to the unexpected result.

Many Great Discoveries Were Not Expected

A young researcher in agronomy initially hypothesises that wheat yield increases with the amount of fertiliser used. They conduct an experiment on a wheat crop divided into several plots with varying amounts of fertiliser. Naturally, they measure the wheat yield for each plot but also other general parameters such as the soil carbon content and weather data. After the experiment, they are disappointed to find that there is no correlation between wheat yield and the amount of fertiliser added. However, there is a correlation between wheat yield and the amount of soil carbon, but the result is ignored as it was not expected. Moreover, their limited knowledge of soil science means that they do not see the potential new discovery.

It is only by chance, during a presentation at a conference, that a specialist in soil science points out that the trend the young researcher thought was insignificant is actually a ground-breaking discovery. The researcher can then reformulate their hypothesis, adjust the background and issues of their article to the theme of soil science and submit it to a soil science journal. Furthermore, if the lack of correlation between wheat yield and the amount of fertiliser is clearly demonstrated, this result can itself be the basis for another article that contradicts current thinking. In the end, the young researcher may have enough results to write two articles, despite initially believing that the experiment was a failure!

Randomness in Research

Expect the Unexpected

The story provides several lessons. First, although it is essential to carefully plan experiments in order to obtain results that can be replicated, it is always possible that unexpected phenomena may be observed. Many major discoveries have been made by chance. An unexpected result can either be published immediately if it is statistically irrefutable or it may be a new avenue for future experiments. A direct consequence of this second possibility is that the doctoral student should not wait until the end of their doctorate to analyse and share their results with colleagues; otherwise they risk missing a research opportunity that could turn out to be very innovative. This story encourages young researchers to measure multiple parameters and record everything. It also highlights how important it is for the researcher to have a broad, multidisciplinary knowledge of science because most significant innovations now occur at the interface between different branches of science.

Finally, the fact that unexpected results might be identified as important by a researcher working in another domain during a conference highlights the importance of exposing your work to a wider public in the hope of discovering something new.

THE EDITORIAL PROCESS

This section describes the various stages a research article passes through in the publication process. It gives authors an insight into how to correct any shortcomings in their article and anticipate the potential problems that may arise when interacting with the journal's editorial team.

A Little-Known World

The Submission of an Article Is Just the Beginning of a Long Road

Researchers know almost nothing about the review, selection and editing process. Doctoral students in particular often seem to believe that publication ends when they submit their article. Consequently, they wait until the last moment, usually six months before they must defend their thesis, to submit an article. Usually, this is too late. I have seen at least twenty cases of doctoral students or their supervisors attempting to exert pressure on an editor to review, and if possible accept, an article. Here are two typical messages, "Please publish my article in your journal" (from a PhD student) and, "This is the first article from my PhD student, he will defend his thesis in four months' time and in order to do this the university requires that he has published an article" (from a supervisor). However, publication in serious journals takes time, even with the benefit of new computer technologies. The following sections describe the long process of review and publication.

Pre-Selection

An Article Must Be Proofread and Corrected at Least Five Times before Submission

Figure 17 shows the main steps involved in processing a research article by the journal Agronomy for Sustainable Development.

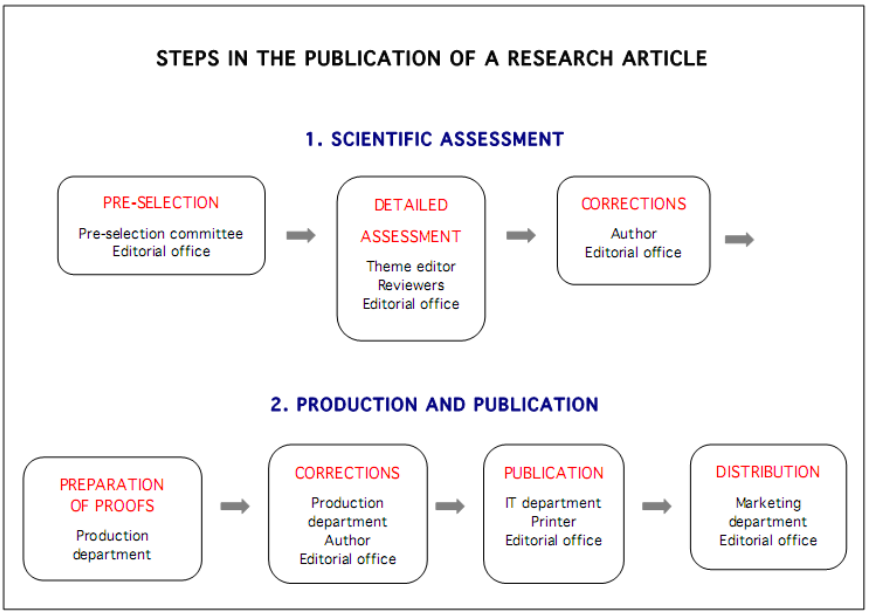

Figure 17. The main stages of publishing a scientific article. The scientific review is managed by the editorial office typically consisting of a chief editor and an assistant. Production and publication are managed by the commercial editor. From submission to distribution and marketing, each article is handled by at least ten people. This is why a failure to strictly follow the instructions given to authors creates problems at various points in the publishing chain and consequently increases the time to publication. IT: information technology.

This process is typical of most scientific journals. The first step is pre-selection. At this point, articles are submitted to the editorial office together with a covering letter and a list of potential reviewers. The pre-selection committee consists of three scientists who are familiar with most of the sub-disciplines that fall within the scope of the journal. The committee reviews submissions in less than fifteen days and produces three reports. About 50% of submissions are rejected at this stage because the committee considers them to be too poor quality for detailed review. The pre-selection committee is also responsible for identifying several theme editors who may be able to undertake the detailed review of submitted papers.

In parallel, the marketing department of the publishing house collects the addresses of the authors and the potential reviewers. The author must ensure that the article is as close as possible to ‘perfect’ before submitting. They must make sure that any instructions are closely followed and check that there are

no spelling mistakes. Such mistakes are unacceptable when they are made by doctoral students, and even more so when they are made by their supervisors!

ASSESSMENT REPORT FOR A RESEARCH ARTICLE

REVIEWER A

Agronomy for Sustainable Development
REVIEW FORM

IMPORTANT NOTES FOR REVIEWERS

- In order to reduce publication delays, please return this form within two weeks
- The name of the reviewer will not be disclosed to the author.
- Please complete this review form then return it by email to the Editor.
- For corrections made in the article file, please return the corrected file by email to the Editor.

Reference:

Title:

Authors:

Reviewer's name: | Date review completed:

1. Overall decision

Accept/Accept with minor changes/Accept with major changes/Reject

2. Rating

Novelty/originality versus current knowledge/methods: X (0-10)

Article clearly focussed on major point(s): X (0-10)

Sufficient experimentation: X (0-10)

Experimental quality: X (0-10)

Statistical analysis: X (0-10)

English: X (0-10)

3. Assessment of specific sections

Title: *appropriate?*

Abstract: *concise summary of work?*

Introduction: *background and problem clearly stated?*

Materials and Methods: *too short/adequate/too long? Acceptable methods?*

Results and Discussion: *too short/adequate/too long? Logical order? Focussed? Correct interpretation?*

Conclusions: *justified by results and correct interpretation?*

References: *appropriate? Right number?*

Tables and Figures: *high quality? Appropriate? Right number? Duplication? Suitable legends?*

4. Specific comments for the attention of the authors

(comments on the whole article)

Figure 18. Assessment form for a research article. This form is completed by theme editors and reviewers.

Detailed Review

If the submitted article is approved by the pre-selection committee, the editorial team will identify a theme editor who then manages the detailed review of the article. At this stage, the theme editor may suggest that the article is rejected if the overall quality is deemed insufficient. Theme editors often prefer to reject an article rather than discredit themselves in the eyes of reviewers by asking them to assess a poor-quality article. If the theme editor accepts the article they then contact at least two reviewers selected for their expertise in the field. The editor may or may not choose the reviewers suggested by the author. The reviewers assess the article and prepare a report for the theme editor. A report template is shown in Figure 18.

Reviewers sometimes also prepare comments on the manuscript that can be very useful in improving the article. Finally, the theme editor sends three reports to the editorial team; the two reviewers' reports together with their own recommendation for the next step in the processing of the article: accepted with modifications, or rejected. The chief editor then reviews these three detailed reports and decides whether to accept or reject the article. If the article is accepted the chief editor reads the article in detail, writes his own report and annotates the manuscript. They he asks the author to modify the article in the light of the four reports and the annotated manuscript. At this point, the article is acceptable, but not yet accepted.

Author's Corrections

Revised Manuscripts Must Be Proofread and Corrected at Least Five Times

The authors must correct their article and submit a revised version together with a covering letter that explains the modifications that have been made. The chief editor then decides whether or not to accept the article. Fifty per cent of articles that have passed the in-depth assessment (25% of all submissions) are rejected at this stage because the author's amendments are not satisfactory. The global rejection rate is therefore 75%. Note that editors prefer to reject an article where many simple changes have not been made, rather than return the article to the author for a second round of corrections. This demonstrates how important it is for the author to do a good job of editing the manuscript and above all to read and re-read it at least five times

before submitting the revised version. Experience shows that there are always a few errors.

Editorial Corrections

When the manuscript has been accepted, the editorial office corrects the remaining errors and makes any necessary improvements to the style and clarity of the article. This step is not implemented systematically in all journals; it depends on the time and personnel available. The editorial office informs the author that the article has been accepted and sent to the editor for the preparation of proofs: the almost-final version of the article.

Production and Correction of Proofs

The production department manages the final preparation and correction of proofs. Proofs are the almost-final version of the article as it will appear in the journal. They are usually prepared using LaTeX software using the raw manuscript for the layout of text and figures. The proofs are converted to portable document format (PDF) and sent to the author and the editorial office for any final corrections. At this point, only minor corrections are possible because the layout is difficult to change. This is yet another reason why the author must deliver a perfect version following the detailed review. In rare cases where the author asks for too many changes, the article may still be rejected for technical reasons.

Publication

The information technology (IT) department draws up an eXtensible Mark-up Language (XML) file for each article in preparation for its publication on the Internet. The article is first published online with a digital object identifier (DOI) but without page numbers. This first version is called ‘E-first’ or ‘Online first’. This version can be cited but does not contribute to the calculation of the journal’s impact factor. However, it helps to make the article visible to the public as quickly as possible. In a second step, the article is published with page numbers, both electronically and more traditionally, in a paper version. The time between the Online first publication and the

paginated publication is about two months. It should nevertheless be noted that distribution modes are changing rapidly and that paper versions will probably disappear in favour of a single, online version.

Distribution

The marketing department manages the promotion and the sale of articles. They work closely with the editorial office and engage in both scientific and commercial promotional activities. These include the preparation of press releases, identifying potential authors to write reviews, writing newsletters, preparing alerts for Internet users, managing mailing lists for researchers and advertising at seminars. Journals are marketed in several forms: through individual subscriptions to the paper or electronic version, the provision of global access to members of research institutions, or more recently online sales through the direct purchase of the PDF version of the article on the Internet.

Time to Publication

Table VIII shows the average time needed for each step in the processing of the article and the number of people involved, excluding the author.

Table VIII. Average time to publication and the number of steps involved in the processing of an article submitted to the journal 'Agronomy for Sustainable Development'

REVIEW AND PUBLICATION OF A SCIENTIFIC ARTICLE			
STEP	HANDLED BY	TURN-AROUND TIME (DAYS)	PROCESSING STEPS (NUMBER)
1. Pre-selection	Editorial office 8 people	15	5
2. Detailed review		70	5
3. Author's corrections		30	1
4. Editorial corrections		5	2
5. Preparation of proofs	Publisher 8 people	20	3
6. Correction of proofs		20	2
7. Online publication		10	2
8. Distribution		10	2
TOTAL	16 people	180	22

The four-month period needed for scientific review corresponds to the first four steps and is the time between submission and final acceptance. It involves eight people and thirteen actions. The two-month time to production corresponds to steps five to eight and requires actions by another eight people. In total, the average time for online publication is six months and involves sixteen people. It is difficult to reduce this time and still maintain a rigorous assessment process.

Some journals have shorter deadlines for publication. For example, prestigious journals such as Nature employ a large number of editors and can turn around articles quickly. On the other hand, journals have recently appeared that are entirely electronic and promote rapid publication. Unfortunately, this is usually because there is no peer review process; these journals publish articles as-is at the expense of scientific quality. Many of them have failed because they are not economically viable in the long term.

ABBREVIATIONS

The Abuse of Abbreviations Seriously Impairs Communication

This section explains the problems that can arise with abbreviations and provides advice on their use. An abbreviation is a shortening of a word or phrase, which is represented by a letter or a group of letters from the word. An abbreviation is pronounced by spelling out the letters, for example DNA. An acronym is an abbreviation that is pronounced like a normal word; Laser, Radar and UNESCO are examples.

> Plant height in NPK and FYM addition was significantly suppressed in EM.

This sentence from a manuscript I reviewed illustrates the problem of using abbreviations in scientific articles. Hitherto little used, they are becoming commonplace, not only in scientific literature but in all fields of communication. They have become the latest fad in science, as Latin has been misused in order to make the author seem more ‘cultivated’ and therefore make the article seem more ‘scientific’. The use of abbreviations is so widespread and some young authors employ so many that the manuscript becomes incomprehensible. For example, replacing efficiency by EF or aboveground biomass by ABG is clearly unnecessary. The use of

abbreviations seriously impairs communication. Communication must be very fast and a reader who finds an unfamiliar abbreviation on page eight will not waste time searching the previous pages for the place where the author explained it. Consequently, the reader is likely to abandon the article and move to another that is more readable. Here are some tips regarding the use of abbreviations:

- The use of abbreviations is strongly discouraged.
- The title and abstract must not contain any abbreviations.
- The only areas of the article where an abbreviation may potentially be necessary due to a lack of space or for clarity are in equations, figures and tables.
- An abbreviation that appears in a table or figure should be systematically explained in the legend.
- Any abbreviation in the text should be explained the first time it is used. It is strongly recommended to explain it again if it appears at a point much later in the text.
- A maximum of three abbreviations is acceptable provided they are really necessary.
- Any abbreviations that are used should be familiar to the broad scientific community. For example DNA for desoxyribonucleic acid, PCR for polymerase chain reaction or GMO for genetically modified organism.

Good writing does not need abbreviations. If the author is writing about soil organic carbon, the phrase ‘soil organic carbon’ will only be required in full at the beginning of the article or paragraph. In the following sentences, it is enough to talk about ‘organic carbon’ or ‘soil carbon’ or even ‘carbon’ so that the text remains understandable, without peppering the entire section with SOC.

Chapter 2

TIPS BY SECTION

THE SKELETON OF AN ARTICLE

This section describes the general structure of a research article and the key transitions between sections.

Although different scientific journals structure articles slightly differently, the most efficient structure for the rapid communication of new results is shown in Figure 19. The title and the abstract are the two most visible sections as they are freely accessible on the Internet. The job of these sections is therefore to convince the Internet user to read the full article. Every word in the title and abstract must be carefully crafted with the utmost attention. The abstract must accurately summarise the entire article, including the introduction, method, results and discussion.

The results and their discussion are presented in the same section for several reasons. First, if the two sections were separate the author would be encouraged to present all their various results and observations, as in a thesis. The article would contain results that were irrelevant to the focus of the paper and it would not be clear what the new result was. Bringing these two sections together requires the author to only select relevant results and focus on the demonstration of a single new finding. Second, two sections would separate the results from their interpretation and the discussion would be ambiguous as the reader would find it difficult to distinguish the results of the study from the results referenced in the literature. Third, to get your message through to the reader the main findings (a maximum of three), their novelty and their implications must appear at least three times in the article; in the abstract, the results and discussion and in the conclusion.

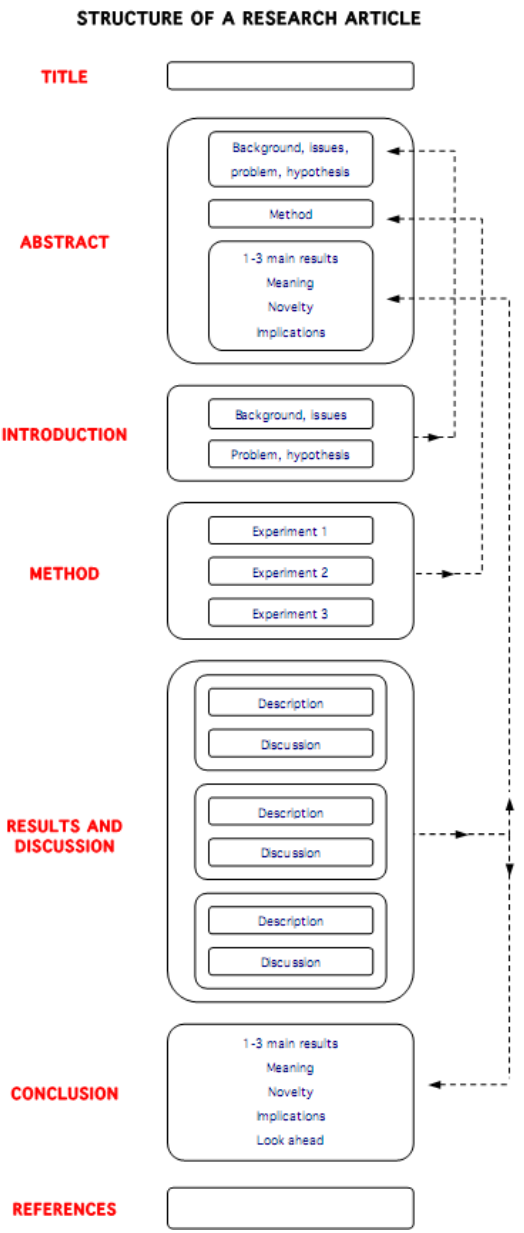

Figure 19. Overall structure of a research article. The arrows show that the abstract summarises the introduction, the method, and the results and discussion. The main findings of the study are highlighted three times: in the abstract, at the end of the discussion of each finding and in the conclusion.

TITLE

This section describes the main problems found in article titles and offers some solutions that particularly emphasise the added-value of the discovery.

Common Mistakes and Tips

Too long

Although it is not always possible, a relatively short and carefully crafted title will have more impact as it focuses the reader's attention on one or two major points.

Too Specialised

The title must not contain jargon that can only be understood by a handful of world experts. It should contain terms that highlight the importance of the context and the broader issues for the general reader.

No High-impact Keywords

To ensure that your article is found by Internet search engines such as Google Scholar the author must ensure that the title includes a few keywords that highlight the general issues placed as close to the beginning of the title as possible. For example: climate change, stem cells, transgenic, pesticide, biofuel.

Nothing New

Wherever possible, the title should emphasise or suggest what is innovative, unexpected or different in the article. For example, the title could include the following words: 'Novel...', 'Unexpected...', 'First…', 'Proof of...', 'Evidence for...', 'Alternative…'

Abbreviations

There should be no abbreviations in the title, except for well-known examples such as DNA.

Brackets

The title must not contain any words in brackets.

Question form

Barring exceptional cases, the title should not be written in question form. A research article is supposed to provide answers or demonstrate an advance.

Examples

Here are some examples of titles that contain words that suggest novelty, an advance or a difference to existing knowledge:

Advances in prospect theory.
Advanced satellite imagery to classify sugarcane crop characteristics.
Alternative strawberry production using solarization.
Mulching as an alternative technique for weed management.
Benefits of plant strips for sustainable mountain agriculture.
Pharmaceutical crops in California, benefits and risks.
Conventional versus alternative pig production.
Discovery of protein biomarkers for renal diseases.
The rediscovery of intercropping in China.
Rhizobium gallicum as an efficient symbiont for bean cultivation.
The emergence of stable isotopes in environmental and forensic geochemistry studies.
Enhanced genome annotation using structural profiles.
Fungal disease management in environmentally friendly apple production.
Fossil evidence for a novel series of archaebacterial lipids.
A fast, robust and tunable synthetic gene oscillator.
First measurements of the ionospheric plasma escape from Mars.
Generation of a prostate from a single adult stem cell.
High decrease in nitrate leaching by lower N input.
High efficacy of extracts of Cameroon plants against tomato late blight disease.
Mechanisms that improve referential access.
Improvement of soil properties by application of olive oil waste.
Innovative materials processing strategies.
New approaches to study the preservation of biopolymers in fossil bones.
A new method for measuring daytime sleepiness.
A novel pathway of soil organic matter formation.
A simple voltammetric procedure for evaluation of As removal from water.

Strong effect of dispersal network structure on ecological dynamics.
Transgenic cotton for sustainable pest management.
Uncommon heavy metals, metalloids and their plant toxicity.
Unconventional states of confined quarks and gluons.
Unexpected cardiac arrest during spinal anesthesia.
Unprecedented ultra-high hydrogen gas sensitivity in undoped titania nanotubes
Unusual superconducting state of underdoped cuprates.

BODY OF THE TEXT

Common Mistakes and Solutions

The origin of results is unclear

In this case, the reader cannot tell whether an interpretation or an implication derives from the results of the author or the literature. To overcome this problem, the author must clearly distinguish their contribution using a personal style (I..., we..., our..., this study...) and, particularly in the discussion, carefully placed references.

Unstructured Paragraphs, Lack of a Unifying Theme

Paragraphs consist of unrelated, orphan phrases. To overcome this problem, the author must remember that a paragraph demonstrates or highlights one idea centred on a common theme. A paragraph is a story or a demonstration that starts in the first sentence and ends in the last sentence.

Isolated, Orphan or Single Sentences

The body of the text must be written in paragraphs that are three to eight sentences long and make one point. Single observations and results that are not explained or related to the main finding must be removed.

Long, conTorted, Complex, Multi-verb Sentences

Unlike the Romance languages, sentences in scientific English must have a single verb. They must be short and simple in the form of a subject-verb complement. Repeating a word from one sentence in another sentence is not considered a defect in English; being understood is the priority. Complex

sentences with stylistic effects are reserved for senior researchers who have had many of their articles published in English in top-quality journals.

Excessive Use of Abbreviations

The latest fad, abbreviations seriously undermine the reader's ability to understand an article. There are only three places where abbreviations are necessary: in a figure, table or equation, usually because there is not enough space to write the entire word or phrase. In this case, abbreviations should be explained in the corresponding legend.

Excessive Use of Brackets

In this case the author makes excessive use of words and phrases in brackets, especially in the middle of sentences. This makes reading very cumbersome and often causes the reader to lose track of the argument. To overcome this problem, the author must replace the brackets by elements such as 'e.g.', 'such as', 'etc.', 'of…' or by adding another sentence. Bracket abuse is often seen in the work of authors who are keen to highlight an interesting point that is unrelated to the main argument of the paragraph. Consequently, the paragraph becomes a heterogeneous mosaic that simply confuses the reader. These interesting but unrelated comments must be deleted. Finally, as far as possible, the author should write their sentences so that any references appear at the end of the sentence.

A writing tip

The author must pay close attention to the first and last sentences of a paragraph. These phrases have greater impact because they are next to blank areas of the page, where the reader slows their reading and 'breathes'. For the same reason, it is particularly inadvisable to cite a reference in the first sentence of the conclusion or the results as it accentuates the problem and takes the focus off your work.

ABSTRACT

This section discusses the main mistakes found in abstracts and explains how to create a structured and effective abstract.

Common Mistakes

- No description of the issues, the knowledge gap and the problem to be solved.
- Lack of education and dissemination in the description of the issues at the beginning of the abstract and no explanation of the implications and benefits of the main finding at the end.
- Lack of structure: the abstract is an untidy mixture of context, method, results and implications.
- Lack of clarity in the origin of results; it is not clear what the author's specific contribution is.
- Results are not supported by statistics.
- Too many results are provided, accompanied by irrelevant comments.
- Results are not explained.
- The author does not explain what the study's findings add to existing knowledge.
- The implications and benefits of the new finding are not explained.
- The explanation of the implications and benefits of the results is vague, general and unrelated to the innovative finding described by the author.

Structure

Figure 20 shows an effective way to structure the abstract. As it summarises the entire contents of the article, it is often the last section to be written. The structure consists of three distinct parts that summarise in turn, the introduction, the method and the results and discussion.

Context, Problem (about 25% of the Abstract, Three Sentences)

This part summarises the introduction, i.e. the context, general and global issues, local and specific issues and ends with the avenue that the article explores.

Method (25%, Three Sentences)

This part summarises the experiment, in particular the method. The author must use a personal style (here we studied…, we measured…, I surveyed…) in

order to clearly distinguish their own contribution. The author outlines the main experiments, the variables and the parameters measured. Important statistics are included, such as how long it took to run the experiment.

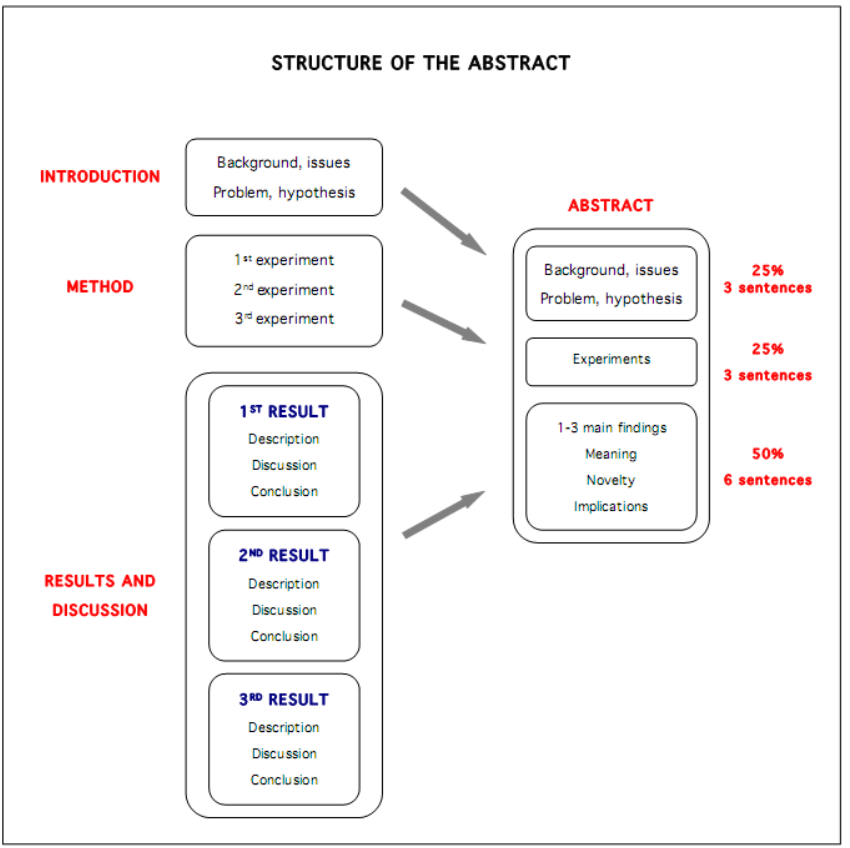

Figure 20. Structure of an abstract. The abstract summarises the entire article, i.e. the introduction, the method and the results and discussion.

The Principal Finding, its Novelty and Implications (50%, Six Sentences)

This part summarises the results and discussion section. Again, the author should adopt a personal style such as ‘our results show that...’, ‘we found that...’ to clearly indicate to the reader that these are the results of the study. It describes a maximum of three results backed up by a few well-chosen statistics. Example: ‘Our results show an increase from 21 to 46 g...’, ‘decrease of 33%...’, ‘an average of 33 ± 2 g’. Then the author explains the

meaning of the finding in terms of novelty, added-value or what it contributes to existing knowledge. Most reputable journals will reject an article if this is not made clear. Finally the abstract outlines, in order:

- the scientific benefits,
- the societal benefits,
- the theoretical and applied implications,
- the specific (or local) implications,
- the general (or global) implications.

In practice, this part of the abstract is prepared in advance. Each subsection of the results and discussion should end with a 'partial conclusion' that encapsulates in one or two sentences the novelty and implications of the subsection. These partial conclusions are brought together in the third part of the abstract and in the conclusion. This technique also has the advantage that the reader is more likely to remember your main finding as it is repeated three times: at the end of the abstract, in the discussion and in the conclusion.

References

The purpose of the abstract is to summarise the work of the author. Therefore, barring exceptional cases, it should not contain any bibliographic references. If you do include references in the abstract it becomes difficult to distinguish between your results and those of the literature. It also makes it difficult to identify what is new in the article. The use of references in the abstract is reserved for senior researchers who are fluent in rhetoric.

INTRODUCTION

This section discusses the main mistakes found in the introduction and explains how to structure the introduction around a unifying theme.

Common Mistakes

Lack of Education, Dissemination, Too Specific

A common mistake found in the introduction is that the author moves directly to a discussion of the specific and local issues without taking the time to outline the general, global and societal issues.

Lack of Structure or a Unifying Theme

The challenges presented do not correspond to the hypothesis.

The Rationale for the Work Is not Explained

The scientific challenges or the knowledge gaps are not explained or are unrelated to the hypothesis. Consequently, the reader finds it difficult to understand the purpose of the study.

Lack of References or Unrelated References

The description of the general issues is not supported by references to review articles or books. The identification of stumbling blocks, current limitations and knowledge gaps are not supported by references to previous research.

Structure

From the General …

The author must create a unifying theme that starts with a description of the general, global or societal issues. They should explain the general background to the study, the issues and the broad problem to be solved supported by references to review articles or books (Figure 21).

The objective is to educate the novice reader by placing the study in a context that they can understand and drawing upon references that cover a broad domain. This strategy also has the advantage that the specialist enjoys a gentle and progressive introduction to the contents of the article.

… to the Specific

The author moves on to a description of more specific, detailed aspects of the work with a description of the specific, local problem that highlights the lack of existing knowledge. This is supported by precise references to previous

research related to a restricted domain. Once the limits of current knowledge have been established, the researcher finally outlines their hypothesis.

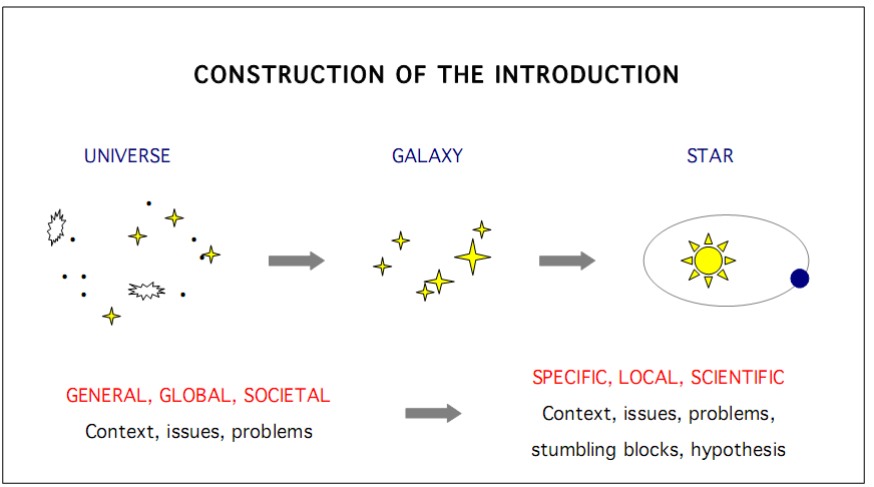

Figure 21. The unifying theme of the introduction. The author weaves together the various elements, starting with general issues and leading progressively to the specific problem.

METHOD

This section describes some common mistakes found in the Method section of an article, and their solutions.

Lack of Structure

The author must organise this section into sub-sections which include:

- general characteristics: location, weather conditions, dates;
- experiments: modalities, time taken, number of trials;
- samples collected;
- analysis techniques and statistical processing.

The Experiment Cannot Be Replicated

The author must clearly explain in detail their methodology and the experiments carried out.

Incomplete Statistics

The author must clearly account for variability in the results and the statistical methods used.

Failure to Identify the Origin of Variability in Results

This is a very common mistake that typically occurs when the reader cannot determine whether the variability (standard deviation) of data comes from:

- the same sample analysed three times;
- or from the analysis of three different samples that are the result of three trials of the same experiment;
- or simple analytic variation, for example the standard deviation of a standard solution analysed three times.

Inappropriate Use of References

The author must explain their method in detail rather than refer to the methods used by other authors.

FIGURES

A Picture Is Worth a Thousand Words

This section describes the common mistakes made in the preparation of figures and provides some tips to improve their readability and the impact.

Common Mistakes

The main figure in the article should quickly communicate the new finding, regardless of how it is presented: graph, diagram, drawing, photography, etc. Therefore, it must be both simple and show enough data to demonstrate the finding. Here are some common mistakes:

- the figure is poorly designed and presented and does not communicate the main finding;
- it is impossible to understand without reading the text;
- it does not illustrate the main finding of the article;
- there are too many figures and not enough text in the article;

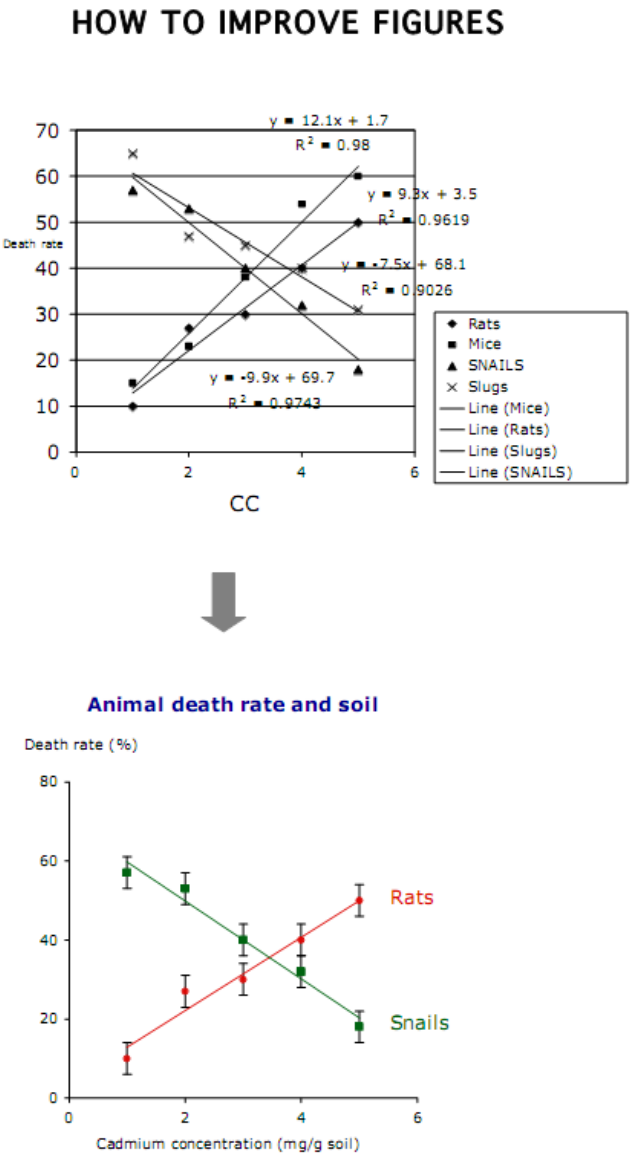

Figure 22. How to improve a graph. Only one or two curves are necessary to show major trends. Other data is explained in the body of the text and all of the data is shown in a table. The legend can be replaced by labels placed next to the corresponding curves. Equations should appear at the end of the legend. The font size must be uniform. Abbreviations should be avoided. A well-chosen title helps readers to understand its purpose.

- it is too complex, there are too many graphs;
- there are too many curves in one graph;
- the legend is too short and does not explain the figure;
- abbreviations are not properly used or not explained in the legend.

Graphs

The main mistakes made when preparing graphs and ways to improve them are illustrated in Figure 22 with a hypothetical example. The first graph presented in Figure 22 shows too much data. In general, two curves are enough to show major trends; the rest of the data is presented in a table and general trends are explained in the body of the text. In most cases a separate legend is not necessary as it can be replaced by labelling the corresponding curves, using arrows if necessary. This helps to avoid using abbreviations. Any abbreviations that are used must be explained in the legend. Regression equations are placed at the end of the legend.

The font size must be uniform and balanced. Axes labels should be specific and include the units of measurement. The title should be informative. The following styles are best avoided or should be used with caution:

- Three-dimensional figures and bar charts or column graphs.
- Graphs with two variables on the ordinate (Y, Z = f (X)) which can be replaced by two superimposed graphs: Y = f (X) and Z = f (X).

The Legend

A figure should be understandable without reading the full text of the article. The best articles are those where the main figure is enough to demonstrate the findings. For this reason the legend should be clear: it is perfectly acceptable to repeat text from the body of the article. Figure 23 shows an example of the various elements of the legend.

RESULTS AND DISCUSSION

Here I describe the main mistakes found in the results and discussion section of an article. Then I explain how to structure this section and its sub-sections.

PREPARATION OF THE LEGEND

1. General description of the figure

Death rate of animals living in soil containing cadmium.

2. Description of trends

The figures shows an increasing mortality rate in rats and a decreasing rate in snails.

3. Meaning of trends

These results demonstrate the resistance of some species to soil cadmium.

4. Equations, abbreviations, notes, etc.

Linear regression: $y = 9.3x + 3.5$ ($r^2 = 0.96$) (rats)...

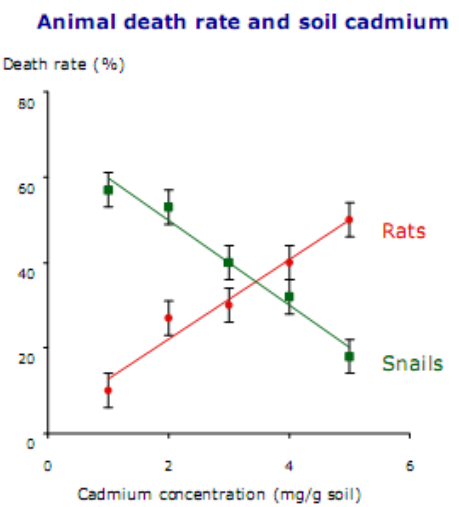

Figure 23. A sample legend. The legend should contain enough information so that the figure is understandable without referring to the body of the text. Note that the legend takes the form of a paragraph: in the example the sentences have been separated for clarity.

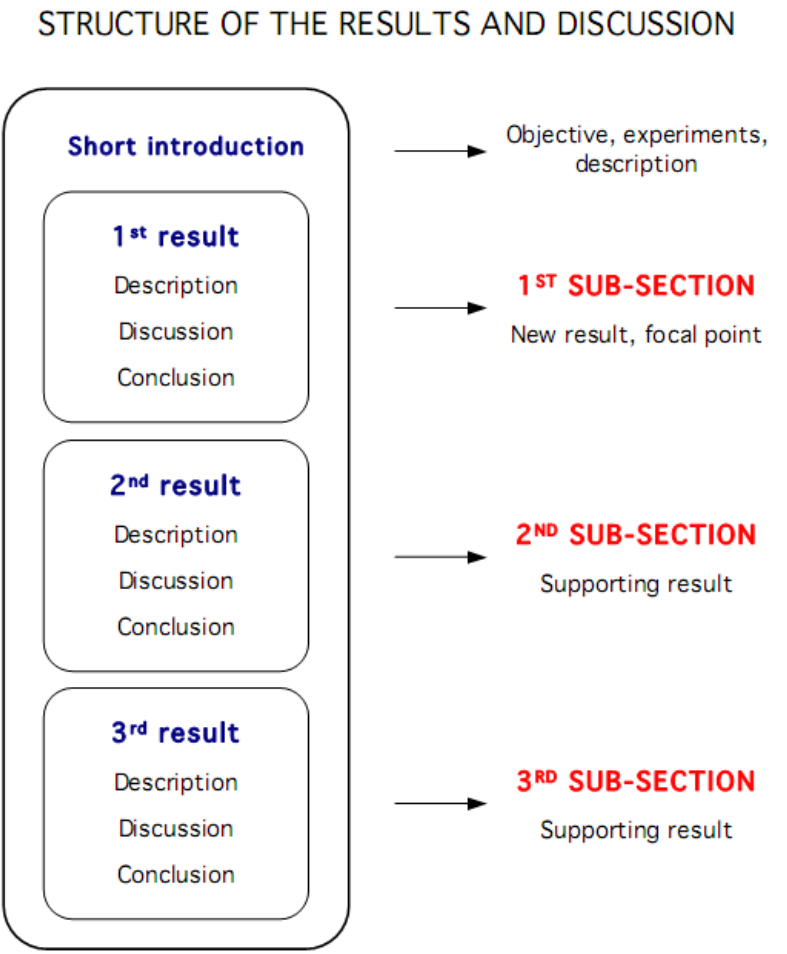

Figure 24. The structure of the results and discussion. After a brief reminder of the purpose of the study and the experiment, the author presents their main findings in themed sub-sections with appropriate headings. The first sub-section highlights the main finding of the article, while other sub-sections contain results that support it.

Common Mistakes

- too many results;
- results and observations are not explained;
- irrelevant results are included and it is difficult for the reader to identify the principal, new finding;

- lack of structure: the reader is faced with is a heterogeneous mosaic that lacks a unifying theme;
- inappropriate use of references that make it unclear where results come from;
- lack of a clear explanation of why the results are new, their added-value or how they are different to existing knowledge;
- the implications of the new results are not explained;
- efforts are not made to educate the reader or to disseminate the findings. There is little explanation of the general implications and benefits of the new results for society.

Overall Structure

Before sitting down to write this section, the author must select one new finding and two supporting results from their various experimental data (see micro-article p. 9). Next, they prepare a well-designed figure that clearly demonstrates the principal finding of the study and two or three other supporting figures.

To make life easier for the reader, the results and discussion should begin with a few sentences that summarise the aim of the study and the experiments that were conducted (Figure 24). These are followed by a sentence that introduces the sub-sections. The topic of each sub-section themes is indicated by an appropriate heading.

Authors should discuss their results using a personal style. For example, ‘this study…’, ‘our results...’, ‘we found...’, ‘our findings demonstrate...’ avoids any ambiguity in the origin of data.

Sub-Sections

Each sub-section describes only one result and is structured as shown in Figure 25.

- First the result is described in detail, backed up by a few well-chosen statistics that support the finding. For example: ‘Our results show an increase from 21 to 46 g (Figure X)’, ‘a decrease of 33%...’, ‘an average of 33 ± 2 g’. This part of the text should not contain

references to previous work as this may confuse the reader. A well-designed figure can help to illustrate the result.

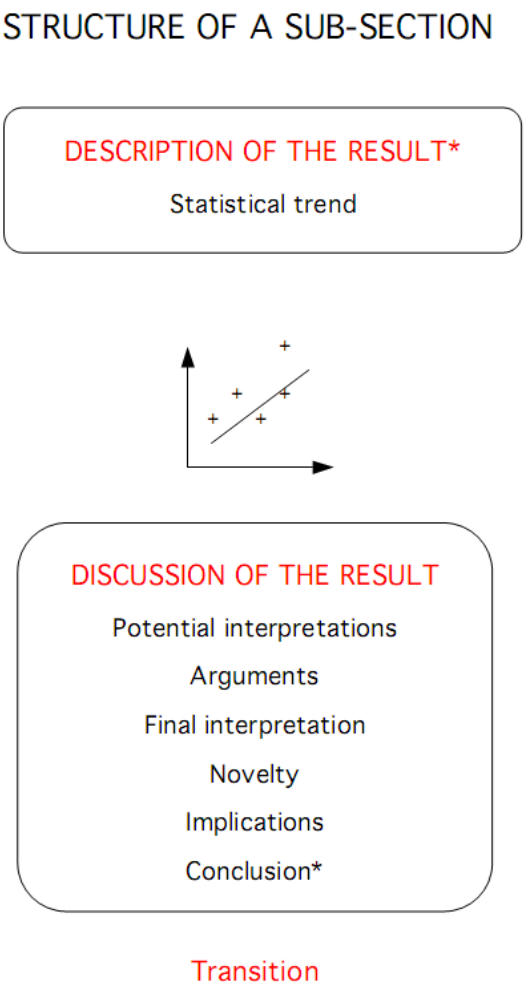

Figure 25. Structure of a sub-section of the results and discussion. * Citing bibliographic references in these parts of the subsection is strongly discouraged.

– Then the result is discussed. The author must take care to build their argument by organizing the text in the form of a demonstration. It is important here to avoid introducing any interesting, but unrelated comments that might divert the reader's attention. For the same reason, references should only be used to support the interpretation of

the hypothesis and the novelty of the findings. Next, the author must explain the scientific significance of the result. For example what is new about it, how it advances current knowledge, its added-value, the innovation or how it is different to existing knowledge. Without this explanation the manuscript is not a research paper. The author then outlines the implications and benefits of their finding first in specific, theoretical and scientific terms, and then in general, applied and societal terms.

- Each sub-section ends with a 'partial conclusion' that repeats in one or two sentences the contribution of the result to the main finding. These partial conclusions are used at the end of the abstract and in the conclusion (see p. 52, 65).
- Finally, one sentence establishes the transition to the next subsection.

Authors are not encouraged to end a sub-section with a bibliographic reference. It obscures the main point of the sub-section and makes it more difficult to distinguish the author's original work from previous work.

CONCLUSION

Here I list some common mistakes found in the conclusion of an article and explain how to organise this section clearly and efficiently.

Common Mistakes

- The conclusion is unrelated to the results.
- The author discusses vague and general issues that are unrelated to the main finding.
- The author continues to discuss and speculate on their results and the implications.
- The author makes general comments that should be in the introduction.
- The author introduces bibliographic references: this section should present the conclusion of their own work, not that of others.
- The author engages in a long and meandering discussion that has no clear theme and obscures the innovative finding.

Some Advice on Structure

Draw Your Own Conclusions

The conclusion is structured the same way as the last part of the abstract (Fig. 26).

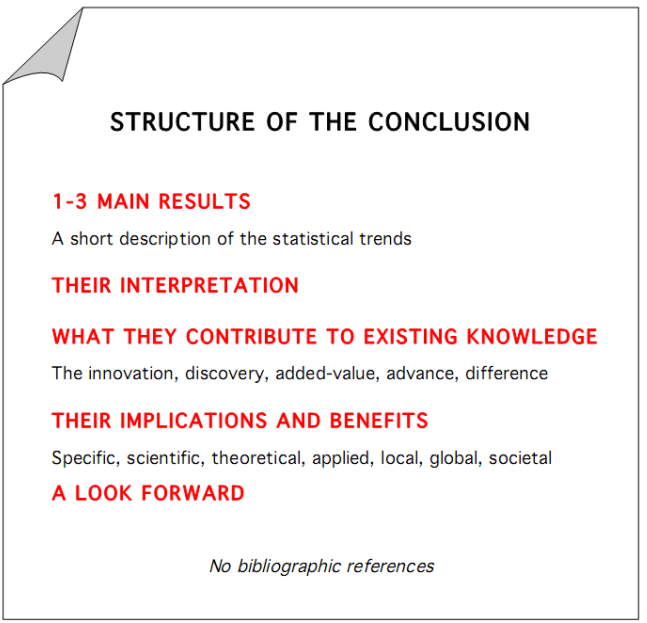

Figure 26. Sample conclusion. The conclusion should remind the reader in a personal and positive way of the main findings, their novelty and their implications backed up by statistical analysis. It should not introduce new material, discuss results, speculate on the findings or contain any general comments unrelated to the innovative result. It may end with a brief look ahead, but it should not contain any bibliographic references.

It is the result of the work presented by the author in the article. Therefore, it should not contain bibliographic references, except in exceptional cases. It should be one paragraph long and focus on the innovative finding demonstrated by the article. The style should be personal and positive, 'here we found...', 'our results show...', 'in this study we demonstrated...' The conclusion does not contain discussion, doubt, speculation or controversy. The words 'could', 'should', 'maybe', 'possible', 'potential', 'presume' and 'hypothesis' should not appear. The conclusion can end with a cautious look ahead. A sample is shown in Figure 26.

BIBLIOGRAPHIC REFERENCES

In this section I discuss the impact of the Internet on the visibility of an article as a result of the bibliographic references. Then I describe the typical mistakes made by authors and offer some solutions. It may also be useful to consult the various other sections of this book that relate to the different sections of an article, including the introduction and the results and discussion. The author must take the utmost care in preparing this section because the list of references is one of the first elements an editor looks at when assessing the quality of an article.

The Impact of the Internet

Authors may be surprised to learn that their list of bibliographic references has an indirect effect on the impact of their article. Many journals have introduced hyperlinks that give the reader direct access to articles that you have cited in your text: the CrossRef system. Once your article has been online for a while, journals also often provide links to articles by other authors who have cited your work. This system of hyperlinks can significantly increase the visibility of your article. However, this only works if your references are correct. Therefore, authors who do not carefully prepare their list of references inadvertently reduce the impact of their article. Consequently, it is essential to ensure that references are completely accurate. Similarly, authors can add a Digital Object Identifier (DOI) to their references to identify an online document. Other stable online references from digital archives, e.g. hal.archives-ouvertes.fr and arXiv.org, are acceptable but authors should avoid using unstable references such as documents found on other websites.

Incorrectly Formatted References

This happens when the author does not apply the instructions for the correct formatting of references provided by the journal. This mistake has three major consequences. First, editors are immediately suspicious as an article with incorrectly formatted references has probably already been submitted and rejected by another journal. Secondly, it suggests that the author is unable to apply simple instructions. Finally, if the article is otherwise acceptable, correcting the format will delay publication by several weeks or

even months. Therefore, the author must rigorously ensure that their references are correctly formatted before submitting an article.

Failure to Cross-Check References

In this case, citations in the text are missing from the list of references and *vice versa*. As with incorrectly formatted references, this suggests a lack of care on the part of the author and reduces their scientific credibility in the eyes of an editor. The author must therefore ensure that all the references cited in the text match with those that appear in the list of references.

Badly Placed References

Barring exceptional cases, the abstract, the results and the conclusion must not contain any references.

Inappropriate Use of References

Authors sometimes use references as a way to demonstrate their knowledge rather than to contribute to a well-crafted manuscript. In these cases, it is difficult to see how the author's arguments relate to the main thrust of the article. Serious researchers do not scatter references haphazardly throughout their article as doing so risks misleading their readers or overshadowing their own findings. Authors are advised to avoid placing references at the beginning or end of the various sub-sections of the results and discussion.

Citing Citations

A problem arises when the author uses a reference to support a claim that is not demonstrated in the cited article itself, but instead by a reference in the cited article. In this case, the author is not citing the source and probably has not checked it. This phenomenon has resulted in considerable distortion of the original facts. Therefore, the author must always cite the source document.

Awkward Sentences

In this case, the author includes one or more citations in mid-sentence or in several places in the sentence. This makes reading considerably more difficult. The best place for references is at the end of the sentence.

APPENDICES

APPENDIX 1.
THE TEN COMMANDMENTS OF WRITING A RESEARCH ARTICLE

1. Select a journal suited to your topic.
2. Apply the author's instructions to the letter.
3. Focus your article on one new finding.
4. Prepare a figure which clearly shows the main innovative finding before beginning to write.
5. Explain your new finding three times: in the abstract, the discussion and in the conclusion.
6. Delete any irrelevant results and any results that are not explained.
7. Distinguish clearly between your results and those of other authors.
8. Include a good dose of education and dissemination.
9. Read and re-read your article at least five times before submitting it.
10. Make sure your manuscript is in perfect English.

If you ignore this advice you risk wasting the time of the ten or so people in the publishing chain who will handle your article. Most chief editors of reputable journals do not have time to spare and will reject at first sight any articles that do not meet the required standards.

APPENDIX 2.
THE NINE STEPS FOR WRITING A RESEARCH ARTICLE

1. Before the experiment. Draft an explanation of the context, issues, the knowledge gap and your hypothesis.
2. During the experiment. Carefully note not just the expected results but also any secondary observations.
3. Following the experiment. Analyse and examine your results in order to identify one main finding, which should clearly demonstrate an advance on existing knowledge. Also select two supporting findings from the rest of the experimental results.
4. Prepare a figure that clearly demonstrates the main finding of the experiment.
5. Prepare a micro-article that distils the essential points around which the final article will be written.
6. Select a journal suited to your topic and carefully check that your article falls within the scope of its specific themes. Read the Instructions for Authors with the utmost attention.
7. Write the method, which should describe the experiment that led to your new discovery. Then write the results and discussion. This should include partial conclusions that can be re-used in the abstract and in the conclusion. Next write the introduction and remember that it must be summarised in the abstract. Finally, write the other sections.
8. Read, re-read and correct the article at least five times. You can do this yourself, but the end result will be better if it is also checked by third-parties who are likely to identify ambiguities and areas that are poorly explained or difficult to understand.
9. Submit your article. It should be accompanied by a covering letter that clearly explains the issues your article addresses and your principal, new result.

APPENDIX 3.
HOW TO WRITE CONSISTENTLY BORING SCIENTIFIC LITERATURE[1]

Kaj Sand-Jensen

Freshwater Biological Laboratory, Univ. of Copenhagen, Helsingørsgade 51, DK-3400 Hillerød, Denmark.

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Although scientists typically insist that their research is very exciting and adventurous when they talk to laymen and prospective students, the allure of this enthusiasm is too often lost in the predictable, stilted structure and language of their scientific publications. I present here, a top-10 list of recommendations for how to write consistently boring scientific publications. I then discuss why we should and how we could make these contributions more accessible and exciting.

"Hell – is sitting on a hot stone reading your own scientific publications"
Erik Ursin, fish biologist

Turn a Gifted Writer into a Dull Scientist

A Scandinavian professor has told me an interesting story. The first English manuscript prepared by one of his PhD students had been written in a personal style, slightly verbose but with a humoristic tone and thoughtful side-tracks.

There was absolutely no chance, however, that it would meet the strict demands of brevity, clarity and impersonality of a standard article. With great difficulty, this student eventually learned the standard style of producing technical, boring and impersonal scientific writing, thus enabling him to write and defend his thesis successfully (Figure 1).

[1] This article is reproduced with the kind permission of Dr Linus Svenson, editor of Oikos.

Figure 1. “Congratulations, you are now capable of writing technical, impersonal and boring papers like myself and the other gentlemen – welcome to Academia”. Drawing by Sverre Stein Nielsen.

Why Are Scientific Publications Boring?

I recalled the irony in this story from many discussions with colleges, who have been forced to restrict their humor, satire and wisdom to the tyranny of jargon and impersonal style that dominates scientific writing.

Table 1. Top-10 list of recommendations for writing consistently boring publications

• Avoid focus
• Avoid originality and personality
• Write l o n g contributions
• Remove implications and speculations
• Leave out illustrations
• Omit necessary steps of reasoning
• Use many abbreviations and terms
• Suppress humor and flowery language
• Degrade biology to statistics
• Quote numerous papers for trivial statements

- Personally, I have felt it increasingly difficult to consume the steeply growing number of hardly digestible original articles. It has been a great relief from time to time to read and write essays and books instead. Because science ought to be fun and attractive, particularly when many months of hard work with grant applications, data collections and calculations are over and everything is ready for publishing the wonderful results, it is most unfortunate that the final reading and writing phases are so tiresome. I have therefore tried to identify what characteristics make so much of our scientific writing unbearably boring, and I have come up with a top-10 list of recommendations for producing consistently boring scientific writing (Table 1).

Ten Recommendations for Boring Scientific Writing

1. Avoid Focus

> "There are many exceptions in ecology. The author has summarized them in four books"
>
> *Jens Borum, ecologist*

Introducing a multitude of questions, ideas and possible relationships and avoiding the formulation of clear hypotheses is a really clever and evasive trick. This tactic insures that the reader will have no clue about the aims and the direction of the author's thoughts and it can successfully hide his lack of original ideas.

If an author really wants to make sure that the reader looses interest, I recommend that he/she does not introduce the ideas and main findings straightaway, but instead hide them at the end of a lengthy narrative. The technique can be refined by putting the same emphasis on what is unimportant or marginally important as on what is really important to make certain that the writing creates the proper hypnotic effect which will put the reader to sleep.

2. Avoid Originality and Personality

> "It has been shown numerous times that seagrasses are very important to coastal productivity (Abe 1960, Bebe 1970). It was decided to examine whether this was also the case in Atlantis"
>
> *Fictive Cebe*

Publications reporting experiments and observations that have been made 100 times before with the same result are really mind-numbing, particularly when no original ideas are being tested. Comparative science requires that particular measurements be repeated under different environmental and experimental conditions to reveal patterns and mechanisms. Therefore, results should be written in a way that does not explain the experimental conditions. This will insure that repetitious experiments remain uninteresting and no synthetic insight can be generated.

I also recommend that these studies be reported with no sense of excitement or enthusiasm. Nowhere in the approach, analysis and writing should there be any mention of the personal reflections leading to this intensive study that robbed five years of the author's youth. This is beyond boring; it is truly sad.

3. Write Long Contributions

> "A doctoral thesis is 300 pages reporting something really important and well reasoned-out – or 600 pages"
>
> *Erik Ursin, fish biologist*

One should always avoid being inspired by short papers, even if they are written by famous Nobel laureates and are published in prestigious journals like Science and Nature. One should insist that the great concepts and discoveries in science cannot be described in relatively few words.

Scientists know that long papers display one's great scientific wisdom and deep insight. A short paper should, therefore, be massively expanded from its original two pages to its final 16-page layout by including more and more details and mental drivel.

4. Remove Most Implications and Every Speculation

> "It has not escaped our notice that the specific pairing we have postulated immediately suggests a possible copying mechanism for the genetic material"
>
> *James Watson and Francis Crick (1953)*

This famous closing sentence suggested a perfect copying mechanism for DNA. Had the implication of their DNA model not been included, Watson and Crick could have prevented its rapid acceptance.

In many other instances, reluctance to state the obvious implications of important findings has successfully delayed their recognition. This has generated room for repeated rediscoveries and insured that the person finally being honored was often not the original discoverer.

Thus, enjoyable speculations on possible relationships and mechanisms and presentation of interesting parallels to neighboring research areas should be dismissed from the paper's discussion. This will stifle the creative thought process and prevent the opening of new avenues for research, thereby securing the research field for that author alone, while retaining the paper's necessary boring tone.

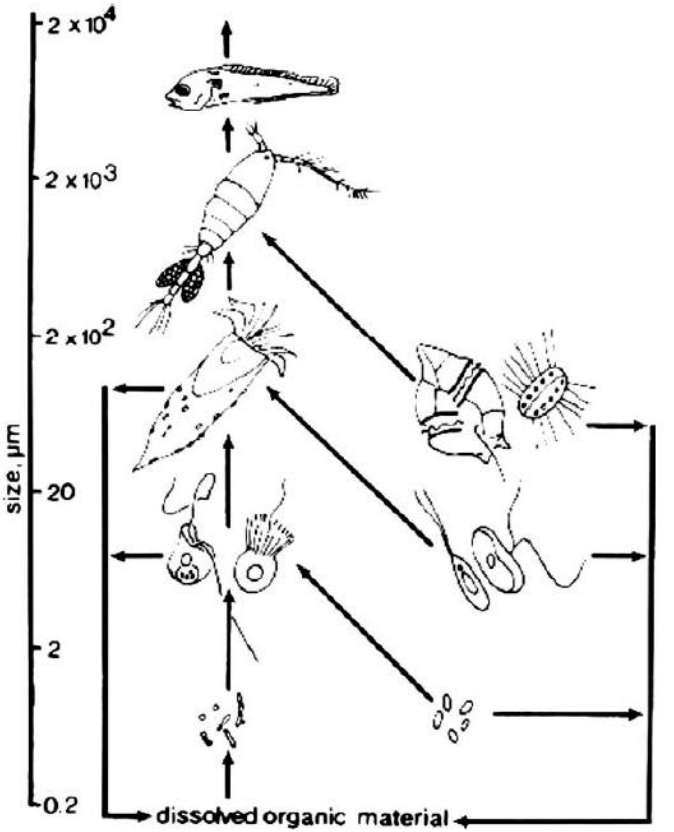

Figure 2. A drawing can say more than a thousand words; the marine plankton food web – including the microbial loop. After Fenchel (1998).

5. Leave Out Illustrations, Particularly Good Ones

> "Examiner: 'What can't you identify on this microscope picture of a cell lying in front of you?' Resigned student: 'A tram car'"
>
> *Jens Borum, former student*

Poetry stimulates our imagination and generates pictures for the inner eye. Scientific writing, on the other hand, should not be imaginative, and the immediate visual understanding should be prevented by leaving out illustrations.

Scientific papers and books can be made impressively dull by including few and only bad illustration in an otherwise good text. Because illustrations, which are fundamentally engaging and beautiful, can often portray very complex ideas in forms that are easy to visualize but impossible to explain in thousands of words (Figure 2), boring science writing should not use them.

6. Omit Necessary Steps of Reasoning

> "I once knew a man from New Zealand who did not have a single tooth left in his mouth. Nonetheless, I have never met anyone like him that could play the drums"
>
> *Freely after Mark Twain, journalist*

Sentences that are needed in an ordinary text to gradually unfold the necessary steps of reasoning and insure the logic of an argument should be omitted in the scientific writings by members of the chosen clerisy of a particular science discipline.

If restricted reasoning is practiced in textbooks, the authors are certain to educate only a very small but elite group of students who may guess the meaning of these words, while the majority of readers will be lost. The style will also effectively prevent communication with ordinary people – a process which is far too time-consuming.

7. Use Many Abbreviations and Technical Terms

> "When I started my geology studies in 1962 what we learned above the level of minerals and fossils was absolutely nonsense. The poor teachers did not understand what they were lecturing, but hid their

> ignorance behind an enormous terminology. All this changed with the theory of plate tectonics"
>
> *Finn Surlyk, geologist (2006)*

Scientists train for many years to master a plethora of technical words, abbreviations and acronyms and a very complex terminology which make up the "secret language" of their specialized scientific discipline. I recommend this approach for all scientific writing, because it tends to enhance the author's apparent wisdom and hide his/her lack of understanding. The approach makes the field of study inaccessible to outsiders who are unfamiliar with the terminology. After all, since we went through all the trouble to learn this "secret language", we must make sure that the next generations of students suffer as well.

This practice will also prevent breakthroughs and interdisciplinary understanding without a massive investment in cooperative translations between jargon-ridden scientific disciplines. It must remain mentally overwhelming for readers to cross the borders between disciplines on their own.

8. Suppress Humor and Flowery Language

> "We found a new species of ciliate during a marine field course in Rønberg and named it Cafeteria roenbergensis because of its voracious and indiscriminate appetite after many dinner discussions in the local cafeteria"
>
> *Tom Fenchel, marine biologist*

Naming a new species *Cafeteria*, or for that matter calling a delicate, transparent medusa *Lizzia blondina*, shows lack of respect and will prevent us from ever forgetting the names. I highly discourage creating these kinds of clever names, because science writing should remain a puritanical, serious and reputable business.

Fortunately, scientists that do not have English as their mother tongue are reluctant to use this wordy language of science to write funny and/or natural flowery narratives. Furthermore, many Englishmen who enjoy this precise and flexible language as their native tongue also regard it as bad taste to use fully in their professional writing the language's potential for poetic imagery and play-on-words humor.

9. Degrade Species and Biology to Statistical Elements

A very special beech forest, located 120 km away, houses numerous rare plant species. There is no reason to make a fuss about this particular forest because the number of common species in a nearby forest is not significantly different.

Our scientific writing in biology should reduce all species to numbers and statistical elements without considering any interesting biological aspects of adaptation, behavior and evolution. The primary goal of ecological study should be the statistical testing of different models. This is especially true because, on further examination, these models are often indistinguishable from each other, and many have no biological meaning. Hence, writing about them will inevitably produce dry, humorless, uninspired text.

10. Quote Numerous Papers for Self-Evident Statements

When all else is lost, and one's scientific paper is beginning to make too much sense, read too clearly, and display too much insight and enthusiasm, I have one last recommendation that can help the author to maintain the essential boring tone. My advice is to make sure that all written statements, even trivial ones, must be supported by one or more references. It does not matter that these statements are self-evident or that they comply with well-established knowledge, add a reference, or preferable 3-5, anyhow.

Excessive quotation can be developed to perfection such that the meaning of whole paragraphs is veiled in the limited space between references. This technique maintains the boring quality of scientific publications by slowing down the reader, hiding any interesting information, and taking up valuable space. When authors are unsure of which paper to cite, they should always resort to citing their own work regardless of its relevance.

Alternative Writing Style and Variable Outlets

There are movements among scientists and editors which are in direct opposition to the disgraceful advices in Table 1. They have the alternative goal of producing exciting and attractive publications for a wider audience.

Many journals do in fact insist that articles must be original, focused, brief and well-motivated, and that technical terms and concepts are fully explained. Very few journals and editors, however, endorse the idea that flowery language and poetic description promote readability or that thoughtful speculations advance the science.

While the original article continues to be the most standardized and efficient (albeit puritanical) outlet of all science contributions, books can, in contrast, provide an alternative venue that encourages personal and entertaining styles of scientific writing that may include humor, poetry and speculations. For example, zoologist Steven Vogel (1994) has combined humor and clear explanations in his books on the application of fluid dynamics to biology. Other exceptional books have played a similar catalytic role in the education of new generations of students and the development of ecology (Warming 1896, Odum 1971).

Over ten years, ecologist John Lawton's (1990-1999) informal essays entertained numerous readers. The basic idea of essays is that they should have few restrictions to their form, but be brief, personal and humoristic. Essays have the additional advantage that they can treat important aspects of scientific activity in the fields between science and politics, science and culture, science and ethics and, the renewed battle field, science and religion. These topics are not normally covered by articles, reviews and textbooks.

Journals should encourage discussion and debate of timely issues and synthesis of ideas within and across disciplines by combing reviews, synthesis, short communication of viewpoints, reflections and informed speculations (Lundberg 2006). In an atmosphere of increasing competition among educations and scientific disciplines, I argue here that we desperately need more accessible and readable scientific contributions to attract bright new scientists and produce integrated understanding.

ACKNOWLEDGMENTS

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