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# Notes on effective scientific writing

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The notes summarise the key areas of the workshop and are designed to help you achieve the following:

- Write in clear, concise and logically structured scientific English
- Develop the sections of a scientific manuscript effectively

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# Writing style

## General advice

Think about your audience(s), the language they use and the jargon and abbreviations they are familiar with. What is interesting and relevant to them? Often readers will not have time to read everything in a document – they may only 'dip in' to what you've written. Therefore, audiences need structure, signposts and logical flow. They will thank you for clear and simple nontechnical vocabulary that describes your research. You do not want to distract your readers through dense text that contains unfamiliar jargon, abbreviations and acronyms.

> There is really only one essential goal in scientific writing: clarity. **Robert Day**
>
> If you can't explain it simply, you don't understand it well enough. **Albert Einstein**

## Constructing sentences

- A sentence should communicate one idea or two closely related ideas.
- Put the most important part of the sentence at the beginning.
- Keep subject and verb together.
- Avoid more than two embedded clauses (i.e. additional information) in the middle of the sentence.
- If a sentence is longer than 30 words, it is often better split into two separate sentences.

Consider this difficult sentence:

> Factors such as root depth, root density, water availability through different irrigation methods and more recently rhizosphere management affect rice crop hydration.

Put the most important part of the sentence at the beginning, keep subject and verb together. Lists are usually better placed at the end of the sentence:

> Rice crop hydration is affected by factors such as root depth, root density, water availability through different irrigation methods and more recently rhizosphere management.

Adding extra pieces of information to a sentence is fine, but adding too much can make the sentence busy and more difficult to read. Consider this difficult sentence:

> If those receiving important emails refuse to have the courtesy to acknowledge receipt, even though they have 'busy' lives, which everyone has, people sending important emails will continue to be frustrated because they are left thinking: "Has he seen, not seen, deleted, ignored or not received my email?"

Here, there are four extra pieces of information – embedded (subordinate) clauses – introduced by subordinate conjunctions (<u>underlined</u>), and the main clause (**bold**) is buried in the middle of the sentence:

> If those receiving important emails refuse to have the courtesy to acknowledge receipt, <u>even though</u> they have 'busy' lives, <u>which</u> everyone has, **people sending important emails will continue to be frustrated** <u>because</u> they are left thinking: "Has he seen, not seen, deleted, ignored or not received my email?".

Splitting the sentence and introducing the main clause first would be easier to read:

> People sending important emails will continue to be frustrated when recipients refuse to have the courtesy to acknowledge receipt. Recipients claim they have 'busy' lives, which everyone has, yet senders are left thinking: "Has he seen, not seen, deleted, ignored or not received my email?"

## Sentences: the active and passive voice

### Active voice

The subject (actor) is placed at the beginning of the sentence and performs an action. The object (recipient) of the action is placed after the verb at the end of the sentence:

> The team calculated the optimum pH.

**Passive voice**

The object (recipient) of the action is placed at the beginning of the sentence. The actor is placed after the verb. This sentence construction needs additional words to accompany the main verb such as '*is, was, are, being* … [verb] … *by*':

> The optimum pH was calculated by the team.

The active voice:

- is clearer and more concise than the passive voice
- puts the subject at the sentence beginning – better if the subject is at least as important as the object.

The passive voice:

- sounds more formal – so invites use in science but…
- sounds duller
- uses more words.

## Should I use the active or passive voice?

Some believe that you should not use the active voice in formal scientific writing because scientific writing should be impersonal. Ultimately, you should use the style of language with which supervisors and coauthors feel most comfortable. Further, some journals provide guidance on writing style and prefer authors to use the active voice (always read a journal's 'Instructions for authors').

Using the active voice does not mean you need to use a person's name or personal pronoun ('*I*' or '*we*'). Take the example: '*Process X improves yield*.' This is the active voice but does not need a personal pronoun. The passive version is fine '*Yield is improved by using process X*.', but it uses more words.

**'*I*' and '*we*'**

It is now acceptable to use 'we' in formal scientific writing. Further, in thesis writing the occasional use of 'I' can be appropriate – for instance when indicating that you have decided to use a particular method from a number of alternatives. However, in disciplines such as the physical sciences, using the first person is often less acceptable. So check with your supervisor, other colleagues and a journal's 'Instructions for authors'.

If you are uncertain about what a passive or active style feels like, compare the following two abstracts. The passive version has nine instances of the passive voice and 131 words. The active version has six instances of the active voice and three retained in the passive: the word count is reduced to 122 words.

Example 1: passive style[#]

> Biosecurity is defined as a set of measures to protect animals and crops from the risk of disease. It is considered important in pig production, and several routine measures are employed by farmers (e.g. cleaning, disinfection, segregation). However, air as a potential vector of pathogens has long been disregarded. Filters for incoming and recirculating air were installed into the ventilation system of one of two barns at a fattening piggery. Over three consecutive fattening periods, the lung health of pigs in the filtered compared with the unfiltered barn was evaluated. Air filtration was easily introduced into the existing ventilation system. Better lung health was found in animals from the barn equipped with recirculating air filtration modules. Therefore, air filtration systems in animal rearing enclosures should be recommended by animal healthcare professionals.

Example 2: active style

> Biosecurity is defined as a set of measures to protect animals and crops from the risk of disease. It is important in pig production, and farmers routinely employ several measures (e.g. cleaning, disinfection, segregation). However, air as a potential vector of pathogens has long been disregarded. We installed filters for incoming and recirculating air into the ventilation system of one of two barns at a fattening piggery. Over

three consecutive fattening periods, we compared the lung health of pigs in the filtered and unfiltered barn. Air filtration was easily introduced into the existing ventilation system. Animals had better lung health in the barn equipped with recirculating air filtration modules. Therefore, animal healthcare professionals should recommend air filtration systems in animal rearing enclosures.

[#]Adapted from: Wenke C. *et al.* (2018). Impact of different supply air and recirculating air filtration systems on stable climate, animal health, and performance of fattening pigs in a commercial pig farm. *PloS One* 13.3: e0194641**.**

When the active voice is appropriate:

- when readers/journals express a preference/expect the active voice
- to avoid/cut down excessive use of words
- to identify the subject and/or take responsibility.

When the passive voice is appropriate:

- the most readable text is often a combination of active and passive voice (as in example 2 above)
- to achieve a balance with the active voice, particularly in the 'methods' section of a manuscript
- when the subject is not known, obvious or irrelevant:

  Artificial intelligence has been the subject of considerable research for decades. (By whom? … It doesn't matter.)

- When the object/recipient is the main topic:

  These dangerous emissions are produced by diesel engines. (When the focus is 'dangerous emissions' and not diesel engines.)

## Smothered verbs (nominalisations)

A verb is 'smothered' when converted (often unnecessarily) into a noun. Scientists often do this – to some it sounds more scientific – yet the verb is often just as good and uses fewer words. Smothered verbs have endings such as '*-ion, -ance, -ent*'. Here are some smothered verbs and their verb equivalents:

come to a decision … decide

provide assistance … assist

make an assessment … assess

**Combining a smothered verb with the passive voice**

A smothered verb is usually as easy to understand as the verb alone. A sentence in the passive voice is no more difficult to read than one in the active voice. But if we combine the two, a sentence can become clumsy, longer and less readable:

A calculation of the optimum pH was made by the team. (Passive voice + smothered verb = 11 words.)

The team calculated the optimum pH. (Active voice + verb = 6 words.)

We calculated the optimum pH. (Active voice + personal pronoun + verb = 5 words.)

If we added subordinate clauses to the first example (particularly more than two), the sentence would become even more difficult.

## Using tenses consistently

You will use different tenses when describing different situations: established facts, a question needing an answer, describing your methods, reporting your results and what other researchers found and believe (or believed?). It can be confusing when you have a different tense in adjacent sentences or different tenses in the same sentence. The key to getting tenses correct is to be consistent for different situations, as illustrated in the following abstract (key: present tense, past tense):

In people with randomenteric disease, symptoms improve using substance X. However, in 2016 Sigmund suggested that substance Y could be a better treatment. We performed a controlled trial to determine

whether Y is more effective than X. We found that Y reduced symptoms in a greater proportion of people than X (y % vs. x %, p-value). We conclude that Y is more effective than X in treating people with randomenteric disease.

Present tense is used in the following situations:

- established fact
- the question asked (or hypothesis proposed) at the time of the study
- the answer and beliefs as a result of the study at that time.

Past tense is used in the following situations:

- attribution to previous work that is not yet established fact
- to describe your methods (what you did)
- to describe your results (what you found).

Some disciplines may use a different scheme, but the important point is to be consistent for the different circumstances.

## Vocabulary, adjectives and adverbs

When using nontechnical vocabulary, here are some guidelines and examples.

Use shorter and more familiar words rather than longer or less familiar words that may sound impressive but which may be more difficult to understand.

advantageous … better

indeterminate … unknown

constituent … part

When there is a simpler alternative, replace a phrase by a word.

serves the function of being … is

in view of the fact that … while, because

it is possible that … perhaps

Remove redundant words.

~~careful~~ consideration

~~definitely~~ proved

~~entirely~~ eliminate

Remove words that simply duplicate the meaning of an adjacent word.

~~each~~ individual

~~various~~ different or various ~~different~~

period ~~of time~~

Use imprecise words with care, such as *'several', 'some', 'many'*. How many objects/people do these refer to? What exactly do '*affect*', '*change'* and '*compromise'* mean? They may be necessary sometimes, but be thoughtful before using them

**Adjectives**

Use strong adjectives when justified: '*urgent'*, '*dangerous'* and '*essential'*. But consider leaving out dubious adjectives: *'particular', 'apparent', 'notable'*.

**Adverbs**

Use adverbs when they add to the meaning of a sentence.

Up to 85% of students mistakenly believe that they are impostors and are not intelligent enough to be presenting their research at a conference. ('*mistakenly'* is essential to the meaning of the sentence)

However, an adverb can reduce the impact of the verb or adjective it modifies.

> Recognising this condition is really important because affected students can be reassured that their perception is false. (‘*really’* reduces the impact of the adjective ‘*important’* and does not add meaning)

## Paragraphs: the basics

A paragraph is not just something that appears when a string of sentences seems to be getting too long, and you decide to hit the return key! (Yes, I’ve done this!) A good paragraph needs careful construction. Ideally, a paragraph has the following characteristics:

- contains a group of related ideas conveyed in sentences (each sentence is an individual idea)
- sentences are in a logical order: most important to least important, earliest to latest …
- sentences flow from one to the next (see below)
- introduced by a ‘topic’ sentence
- concluded with a ‘wrapping up’ sentence.

## Paragraphs: flow from one sentence to the next

In the following paragraph, you will see a topic sentence followed by a series of related ideas in a logical sequence. The sentences are all constructed in a similar way, which makes them seem monotonous. The sentences seem ‘jerky’ and do not flow nicely from one to the next. Further, the paragraph lacks a good ‘wrapping up’ sentence:

> The impact of screen time on psychological health is controversial. Smartphone use in younger people has consistently increased in recent years. Controversy always arises around the appropriate use of new disruptive technology. The arguments often collapse into scaremongering claims. We remain influenced by correlational findings. The confusion continues. We need to critically appraise current research. We need to identify the key questions. We need to determine what research is needed to answer these questions.

Compare with this edited version:

> The impact of screen time on psychological health is controversial. In recent years, smartphone use in younger people has consistently increased. Controversy always arises around the appropriate use of new disruptive technology. However, the arguments often collapse into scaremongering claims, and we remain influenced by correlational findings. Consequently, the confusion continues. To progress, we need to critically appraise current research, identify the key questions and determine what research is needed to answer these questions.

The following techniques have been used to improve the impact and flow of the paragraph.

- The beginning of some (but not all) sentences has been changed to add linking words and phrases (see table below).
- Some short sentences (containing related ideas) have been joined together, without making the resulting sentences too long.
- A more memorable, concluding (wrapping up) sentence has been constructed from the last three sentences using ‘parallel construction’. Parallel construction is when a list is presented in which each element of the list is written with the same grammatical construction. So … *‘appraise … identify … determine …’* are all verbs in the present tense.

| **Linking method** | **Examples** |
|---|---|
| Circumstance | |
| Sequence | *Also… Moreover… First… Second… In addition… Next… Finally…* |
| Restatement | *That is… To put it another way… To reiterate… In other words…* |
| For example / pause | *For example… For instance… such as… like… Similarly… Likewise…* |
| Reason | *Because… Since…* |
| Consequence | *Therefore… So… Thus… Hence…Consequently… Accordingly…* |

| Linking method | Examples |
|---|---|
| Denied consequence | *Nevertheless… However… In Contrast… Conversely… Alternatively…* |
| Concession | *Although… In spite of… Despite… Notwithstanding… While…* |
| Similarity | *Similarly… In a similar way… As with… Like… Likewise…* |
| Addition | *Further… Furthermore… In addition… Also…* |
| Conclusion | *In conclusion… To conclude…* |
| Summary | *In brief… To summarise… In summary…* |
| Other linking methods | |
| Verb infinitive | *To progess… To determine… To improve…* |
| Adverbial phrase | *In recent years.. With confidence… Without exception…* |
| Adverb | *Recently… Immediately… Controversially…* |

## Other factors influencing the readability of documents: organisation and appearance

Writing style, vocabulary and idea flow are major determinants of the readability of a document, but don't forget that organisation and appearance are also important.

## Organisation of documents

A manuscript usually has an accepted order and title of sections: introduction (or background), methods, results and discussion (+/- conclusion). Whilst the order may vary a little and some disciplines have additional sections, we don't usually have to concern ourselves with manuscript structure. However, for many other documents such as a report, review or thesis, the way the document is organised is critical. Good structure allows readers to follow the story/argument easily and to 'dip out' and find their way back in easily. Poor structure makes a document hard work and readers may not grasp the importance of your work or understand your arguments. Here are some key thoughts when organising longer documents.

**Sequence of chapters/sections**

This is probably where you will start when planning to write. As your document evolves, your chapters, sections and subsections will change name and sequence. A good planning tool may help such as MS Word Outline View or electronic mind-mapping. Whilst a deadline may be looming, the more time you spend planning the organisation of a document then the easier the writing becomes.

**Headings and subheadings**

Use headings and subheadings unless guidelines advise otherwise or the type of document you are writing does not typically have them. They rapidly tell the reader what's coming, and they quickly allow readers to find the place in a document again after they take a break.

Use useful headings – '*The motion detector*' is not as helpful as '*The motion detector: how its sensor works',* which is more specific.

**Capitalisation**

When considering how to format your titles and subtitles, always follow a journal's 'Instructions for authors' or a style guide on capitalisation. Journals often ask authors to use 'Title Capitalisation' for titles and subtitles. However, if you are free to decide for yourself, consider the following:

Sentence capitalisation is easiest to read and kindest to your readers

Title Capitalisation is More Difficult to Read and Can Lead to Inconsistencies in capitalisation

ALL CAPITALS IS MOST DIFFICULT TO READ AND BEST AVOIDED

Particularly for slides presented at a conference when your audience has only seconds to read the title of your slide, ALL CAPITALS is certainly best avoided. May argue that sentence capitalisation is the best format whatever the circumstance: consider your readers!

**Vertical (bulleted or numbered) lists**

We all know how much easier it is to read and remember information when presented in a vertical bulleted or numbered list. Typically, such lists do not appear (and are not needed) in standard manuscripts, journal reviews and theses. However, think if they may be useful for reports, book chapters, websites and many other documents. I use many such lists in this tutorial.

**Signposting**

This technique helps readers move from one topic/section to another. Typically, signposting is used at the beginning or end of a section – giving a brief summary of where the reader has been and where the reader is now being taken. For instance:

> We have now discussed the place of this new motion detector. The next section describes how it works and the limits of its detection abilities.

Note that this is different from the unhelpful practice of wasting words – phrases or sentences that do not help:

> Three problems arise. Firstly… Secondly… The third problem to consider is…

Introducing the third problem with an unnecessary phrase has wasted words and not been helpful. '*Thirdly..*' is sufficient.

## Appearance of documents

It's a shame that after months or years of quality research, text describing a relevant and interesting topic can be written in a form that looks challenging to read. Compare text example 1 with example 2:

Example 1

> Lorem ipsum dolor sit amet, sit eu consul discere, stet reprimique ex nec. Vim option virtute no. Vel utamur labitur democritum ne. At movet legendos pertinacia pri, vix ne liber legere, ex vitae perfecto omittantur eum. Decore verear sit ex. Ne duo saepe cotidieque, vel at soluta vocent voluptatum. An vix ignota timeam. Integre partiendo est ut, te nam enim novum meliore. Cu iriure vivendum conceptam nec, id facer oratio salutatus nam. Qui ea dicta timeam constituto. Alii errem te his. Delectus electram no usu. Vero eligendi at est, per no unum audiam appetere. Tacimates iracundia vis ei, per delectus mediocritatem no. Id enim oratio possit vis. Ne pri liber graeco. No vix stet pertinax adolescens, pro id legere feugait, te vix falli mandamus.

Example 2

> Lorem ipsum dolor sit amet, sit eu consul discere, stet reprimique ex nec. Vim option virtute no. Vel utamur labitur democritum ne. At movet legendos pertinacia pri, vix ne liber legere, ex vitae perfecto omittantur eum. Decore verear sit ex. Ne duo saepe cotidieque, vel at soluta vocent voluptatum.
>
> **Add subtitles and lists**
>
> An vix ignota timeam. Integre partiendo est ut, te nam enim novum meliore. Cu iriure vivendum conceptam nec, id facer oratio salutatus nam. Qui ea dicta timeam constituto. Alii errem te his.
>
> - Delectus electram no usu. Vero eligendi at est, per no unum audiam appetere. Tacimates iracundia vis ei, per delectus mediocritatem no.
> - Id enim oratio possit vis. Ne pri liber graeco. No vix stet pertinax adolescens, pro id legere feugait, te vix falli mandamus.

Which looks easier to read? It's about 'white space'.

## White space

White space is created by headings and subheadings, images and diagrams, vertical lists, and the space between paragraphs. Documents with generous white space appear (and actually are) easier to read and navigate. So, when appropriate, try to introduce white space.

When submitting a manuscript to a journal, you have limited ability to plan the appearance of each page. The journal will format your article and '*Figure 2*' may not appear on the same page as '*X decreased more quickly than Y (Figure 2).*' This is inconvenient for the reader. However, even for a manuscript, you do have control over the size of your paragraphs. Therefore, for any document that you write, try to avoid paragraphs that take up half a page because they look scary and uninviting to read. The most inviting paragraph arrangement is paragraphs that vary in size – but no enormous paragraphs! You do have full control over the appearance of your thesis, dissertation and many other documents. So, use all the above tactics to make your writing look inviting.

## Summary

The writing style most enjoyed by readers is usually one which contains varying sentence and paragraph length, familiar (nontechnical) vocabulary and a blend of the active and passive voice.

- Construct simple, clear sentences and consider splitting sentences above 30 words.
- Consider using the active voice when appropriate.
- Avoid smothered verbs.
- Keep acronyms and abbreviations to a minimum; define any unfamiliar ones at first use.
- Use tenses consistently.
- Don't be afraid to use familiar (and shorter) nontechnical words.
- Think about paragraph construction and ways to make sentences flow from one to the next.
- Aim to organise the chapters/section of your documents in a logical sequence.
- Remember that the appearance of your document is important, white space being key.

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## Writing a manuscript

Writing a manuscript can be a scary challenge for researchers early in their careers. However, the task can be made easier if you are armed with ideas about how to plan your writing and guidance on best practice for constructing each section of the manuscript.

### Planning to write a manuscript

Staring at a blank piece of paper hoping that writing appears by magic on the page is not a good way to start. However, here are some ideas to help you plan/start to write.

**Write up the methods first**. Many argue this is the easiest section of a paper to write because you are simply describing what you did.

**Begin by preparing your key figures and tables**. Usually, these illustrate your main messages. For each, prepare a sentence or two that summarises the findings. Together, these will summarise the messages you intend communicating to your readers. They will also form the basis of the conclusion at the end of the paper and the conclusion in the abstract.

**Write a 'problem statement' (sometimes known as an 'elevator pitch')** before tackling the introduction and discussion. This is a short paragraph with a sentence or two that describe the general problem area, the specific problem addressed and the extent to which your research has addressed the problem (the contribution). Here is an example:

> **General problem area…** Within UK hospital information networks, around 5,000 data breaches were reported in 2017. **Specific problem addressed…** However, it is not known to what extent the lack of employee awareness about data security contributes to such alarming figures. We report the results of 100 interviews with healthcare staff within a large NHS trust. **Contribution…** Many areas of ignorance about data security are uncovered. We provide recommendations to help network administrators increase awareness and reduce the risk of employee-initiated data breaches.

Unless you are able to write such a summary, you may not be sufficiently clear about what you want to tell your audience. It certainly concentrates the mind if you have a go at this.

**Use an electronic mindmap**. Even if you are only at the beginning of your research (but as early as possible), enter the four sections of a manuscript on your map: introduction, methods, results and discussion.

- Add or edit your mindmap whenever you wish to add or change anything in the final manuscript. For example, state the question, use a method, report a result, group ideas together, change the order of ideas or have an idea about how your findings relate to another researcher's work.
- Crucially, write your notes in sentences or at least include a verb when expressing an idea. Verbs bring meaning to a sentence and every sentence in your final document will need a verb!
- Copy citation fields from your reference manager and paste them after entering ideas that cite other authors.

Your mindmap will grow and you can move ideas around as you wish. A mindmap does not look anything like a manuscript, but modern electronic mindmaps can finally be exported to Microsoft Word and LaTex. When linked back up with your reference manager, you have your first draft: sections, groups of related ideas in sentences (or at least including a verb) that will become your paragraphs, citations and reference list.

### Introduction

When readers reach the end of the introduction, they should understand why the study was done and why it is important. They should be clear about the problem and should want to read on!

However:

> If the problem is not stated in a reasonable, understandable way, readers will have no interest in your solution.' **Barbara Gastel and Robert Day**

Here are some guidelines for writing your introduction.

Provide **relevant** information

- Include only what the reader needs to know – not a history lesson, not a literature review.
- Aim to elevate your reader's knowledge from reasonable starting point.
- Don't start with something everyone knows or information that is not relevant to the study.

Demonstrate **relevance** to science

- Modestly, say why the study is important and original.
- Say what aroused your interest – why is the study exciting?

Deliver a clear and logical **rationale** (an argument in support of the research).

- Start with the broad context of the problem and what is established knowledge.
- Introduce what is not known and/or what is a problem.
- Then propose a research question and/or hypothesis to be tested.
- Finally, summarise the approach you will use to answer the question/test the hypothesis.

So, the sequence is: context – problem/unknown – question +/- credible hypothesis – approach.

Be mindful of busy readers. Many introductions are too long and readers can get bored or lose focus. Ideally, the last paragraph conveniently summarises the question/hypothesis, the overall method and why the study is important. Indeed, many skimmers will go straight to the last paragraph of the introduction rather than reading the whole introduction. (In some disciplines, the introduction finishes with the main findings and contribution.)

## Methods

One of the commonest reasons for papers to be rejected by journals is when peer reviewers consider that the method(s) could not be repeated by others.

> The cornerstone of the scientific method requires that your results, to be of scientific merit, must be reproducible; and, for the results to be judged reproducible, you must provide the basis for repetition of the experiments by others. **Barbara Gastel and Robert Day**

The materials and methods section is simply a recipe. If you used a well-documented method, just cite the original author(s) and paper that described the method. If you modified or developed a new method, you should describe its validation and give a detailed description of the method – sufficient for someone else to repeat the method.

Methods should be as long and detailed as necessary, but as concise and readable as possible. The acid test of a good description is to ask a colleague if they could repeat your method after reading your description. Readers should be clear about the following:

- selection and source – materials/animals/volunteers
- study design – specifically describing temperature, time, dose, species
- outcome measures
- statistics – techniques, randomisation, power, specified p values
- ethics – approval if required (end of participant section).

Help the reader:

- use subheadings – often these can be similar/identical to the corresponding results
- use tables/flow charts/diagrams if needed/allowed.

## Results

You should be clear about whether your results section is presented separately from the discussion (the commonest format) or in combination with the discussion. This advice refers to an independent

results section. It should provide the results in a way that allows the reader to answer the question without having to refer to the methods section.

The result section should achieve the following:

- present the most important and relevant results in a logical sequence
- provide good figures/tables each with a helpful description summarising the relevant method (this is often called the legend)
- avoid wordy repetition of information presented visually.

The result section should not do the following:

- provide all results – for a manuscript, authors need to be selective about which results to describe, but they must provide the relevant results
- repeat in body text repetitive data that are better presented in figures and tables
- attempt to draw conclusions (save for the discussion)
- attempt to relate findings to other work (save for the discussion)
- usually include methods except in the legends
- usually require references.

Here is some language to be careful with.

Reserve the term '*significant*' for a statistical finding. If authors consider that something is important or may have considerable impact, then use '*important*' or '*considerable*' (and only in the discussion!).

Be careful with adverbs that give a subjective opinion of size of a numerical value. Thus, avoid statements such as '*markedly increased*' or '*greatly reduced*'. Yes, '*increased*' or '*reduced*', but you could say '*three-fold increase*' or '*95% reduction*'.

## Discussion

Generating a good discussion is an academic and writing challenge: placing the research in context with current opinion and other researchers' findings, justifying the contribution and using appropriate language of scientific argument to achieve this. However, some find the discussion the most difficult part of a manuscript to write.

Ideally, a typical discussion should be well-structured present the following:

- a summary of the main findings – best located in the first paragraph
- strengths and weaknesses of the study
- strengths and weaknesses in relation to other studies/theories
- a balanced conclusion
- unanswered questions and future direction.

Conversely, try to avoid the following commonly found problems:

- failure to provide a balanced implication of the results – your results 'in perspective'
- beginning with a second introduction
- repetition of all the results
- an unstructured argument
- inclusion of irrelevant material
- overinterpretation of results – 'marketing spin'.

The discussion can be a daunting part of a manuscript to read. As for the introduction, readers will thank you for a relevant and focused discussion that does not go for page after page!

## Abstract

Write the abstract last. It is impossible to do otherwise because an abstract should only ever be an accurate reflection of the manuscript and should not include any information that cannot be found in

the manuscript. The abstract quickly answers four questions to enable the reader to decide if they want to look at the whole manuscript:

> Why did you start? What did you do…? What did you find? What do your findings mean?
> **Maeve O'Connor**

One of the biggest challenges is to condense all the above information into as few as 150–200 words. Here is a technique that may help, though this will depend on the discipline and type of research.

- **Background**: keep it short and relevant.
- **Methods**: kept to a minimum (unless a 'methods' paper).
- **Results**: should be the bulk – perhaps up to 50% of the abstract.
- **Discussion**: usually not needed.
- **Conclusion**: essential.

The abstract is the ultimate test of your ability to be clear and concise: delivering the relevant facts in as few words as possible. Readers of abstracts are not looking for flowing prose, signposting or other techniques used in, for instance, a compelling introduction or review.

So, you will need to consider the following:

- use short sentences
- use simple, specific words
- edit out 'waste' words
- be consistent as you use mixed tenses – you will have present and past tenses close together
- use the active voice where appropriate
- don't be afraid to use first person ('*we'*)
- take care to explain any non-SI abbreviations.

Finally, here are some common errors to avoid when writing your abstract:

- background too long – uses up valuable words
- question omitted or vague – so we must guess the question!
- answer not stated – so we must guess the answer!
- a result summarised (*'X was more effective than X*') without numerical data to support it (*60% vs. 20% … statistics*)
- too many results – just the main ones because you can't get all results in the abstract
- 'conclusion creep' – the abstract conclusion contains something different from or in addition to the main manuscript conclusion.

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## Resources


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