

Hints for scientific writing for the biomedical sciences

#1 tip of writing: Read

By far the best thing you can do to improve your scientific writing abilities is to increase your reading of quality scientific papers. Read extensively, read in the journals that you want to publish in, read beyond your direct expertise and read in detail. Each of these is important:

- By reading extensively, you get a good idea of the different styles of writing and you can find a style that appeals to you. Identify an author who consistently publishes very well in your field – read a dozen papers from that author and see how they do it.
- Read in the journals you want to publish in. If you want to publish in Nature, you need to read a lot of Nature papers. If you can't find many in your field of research, that is a pretty good sign that you are aiming for the wrong journal. Reading in the journals that you want to publish in means you become used to the journal style and can start to emulate the correct writing style.
- Read beyond your direct expertise. We all have a deluge of relevant papers being published that we can never catch up on, so it is tempting to just read the most relevant. Make sure you resist this and read at least one paper slightly off topic per week. Why? Firstly it is good to expand your expertise and look for potential cross-over of ideas and techniques. Secondly, the best research journals are the generalist journals, which cover a wide area of research. To get into these journals you need to learn to write for a non-specialist, which means you should read as a non-specialist.
- Read in detail. Take a really outstanding paper in your field. You've probably read it multiple times and flick down to the figures or the key points. Read it again, this time slowly and in detail. Spend the whole day reading that one paper and think about the wording they used, how they linked themes together, how they integrated the text with the figures. Think about which parts of the literature they chose to mention in the introduction, look at the level of detail in the methods and think about the content of the discussion. Take a look at your own paper, and then think about how you can apply the lessons from an expert to your own work.



Choosing a journal

It is commonly said that you should submit to a journal one higher than you think you would make. However as the notes below will demonstrate, submitting a manuscript should involve substantial effort in redesigning the paper to suit the journal. So submit to the highest level journal that you believe will realistically review your paper. Have your plan B journal picked out, and even reformat your paper while you are waiting so that you can send it off within 24 hours of your rejection. Rejections are fine – if your papers get accepted first journal every time then you are probably aiming too low.

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#2 tip of writing: what each section of a paper is – and isn't

The advice below is for a generic “biomedical science” journal. Some journals (Nature, Science, the Lancet, etc) have quite different formats, and clinical trials journals in particular have very different rules. In general, rule #1 over-rides rule #2 – read the journal you are submitting in and write in the style appropriate for that journal!

Title

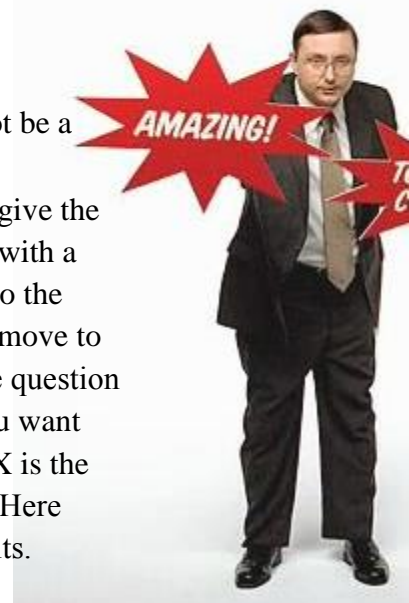
- The title is not a method or aim. Eg, it is not “The effect of IL-18 on murine hepatocytes”.
- The title is the main result. Eg, “IL-18 induces apoptosis in murine hepatocytes”. Once you have your basic title write at least five different titles: “IL-18 is pro-apoptotic in murine hepatocytes”, or “A systematic assessment of cytokines reveals IL-18 as the sole mediator of hepatocyte apoptosis”. Then ask around to see what people think sounds the most interesting and go for that one. I commonly send drafts to coauthors with a selection of titles still given.

Abstract

- The abstract is not the first thing you write and is certainly not a literature review.
- The abstract is the last thing you write and is a summary of each part of the paper. The first 1-2 sentences should be the background as to why your research question is important. The next sentence should be the general method. The next ~2 sentences are the key results (note, methods results can be combined, so you might have a sentence that is half method half result, followed by another sentence that is half method half result). The final sentence is a key point from the discussion as to how this information could be more broadly applicable. Remember that your title/abstract may be the only part of your paper that an editor reads before making a decision, so spend a lot of time making every word count. This is the most important sales pitch of your research! All the rules below apply, as the abstract is a microcosm of your paper.

Introduction

- The introduction is not a literature review. The introduction should not be a balanced survey of the field, and it should not be overly long.
- The introduction is a sales pitch based on the literature. The aim is to give the context for your paper being important. The introduction should start with a paragraph on the essential background to this work. Not background to the field, but to this particular piece of work. The next paragraph should move to outlining what isn't known. This should be specifically targeted to the question you answer in the paper. Essentially, at the end of the introduction you want the reader to think “someone should really do experiment X”, where X is the experiment that you actually did. The final few sentences can be the “Here we...” sentences, where you briefly outline the methods and key results. Overall, the introduction only needs to be 3-4 paragraphs in length.




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Methods

- The methods are not a protocol. They do not need the level of detail of a protocol or methods in a thesis. Typically you don't need to state obvious parts such as washing for a generic technique (eg, flow cytometry).
- The methods are an outline of what you actually did, with references to make it reproducible. Make sure you include references and genetic background for all mouse strains and clone names for all antibodies. Keep it brief, containing only the essential information required to repeat your experiments.

Results

- The results section is not just results. The number one mistake I see in first drafts is that the results section only has the basic facts (“we did this, the results were that”). This is boring to read and hard to understand, because the reader doesn't find out why you did it or what the results mean until the discussion.
- The results section needs to include the context of the results.



Each paragraph should *start* with one sentence (or even half a sentence) giving the context as to why you did this experiment. Even if it is as brief as “In order to determine whether X can Z, we...” or “as an independent confirmation of X we...” it is enough for the reader to understand why this experiment was done. Then when you give the results, remember that the figures can give the detail and you just need to give the results summary. For example, it is enough to say that “addition of IL-1 prevented the upregulation of MIP-5 in splenic dendritic cells (Fig 1b). Similar results were observed in dendritic cells from lymph nodes (Fig 1c)”. You don't need to give the concentration of IL-1 or the numbers for the upregulation (“from 12.3mg/ml during stimulation in the absence of IL-1 to 1.3mg/ml during stimulation in the presence of IL-1”). These details can be added if they really contribute to the story, but the figures are really the place to communicate the fine detail of the results.

Within each results paragraph you need to link experiments together into a single narrative. That means the description of the results of one experiment should naturally lead into the rationale of the next experiment. If you focus more on the narrative of the results and how they build up together into a single story then you will have a much more readable paper. This means that it is more important to have good linkers between each experiment than to detail the results.

Equally, at the *end* of each paragraph you should have a sentence that tells the reader what the results in that paragraph mean (eg, “Together these results formally exclude...”). Do not wait until the discussion to do this, the reader needs to know what each result means as they read it.

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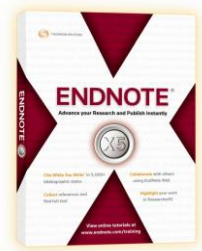
Discussion

- The discussion is not a rehashing of the results section. A good results section should already include brief statements of what you did and what it meant. Do not refer to figures in the discussion – if you need to refer to figures then what you are writing belongs in the results section.
- The discussion is a discussion of your results *in the context of the literature*. At the most you can have one paragraph reiterating the key conclusions of your paper. The rest of the discussion (or indeed, the entire discussion), should be discussing what these results mean in the broader context. If you looked at the effect of SCF on gene expression in neurons, then discuss what biological contexts exist where neurons would be exposed to SCF and what the gene expression changes induced could mean. Discuss how SCF has different effects on neurons (your work) to other cell types and why this might be the case (evolutionary advantages vs detrimental effects). The discussion is the place for you to speculate, think broadly and to demonstrate that your research has wider implications than simply the results you describe. Avoid the clichés of “study limitations” (unless it is for a clinical journal, or you add a section in response to reviewers) and “this area needs further work”.



References

- Use Endnote. It saves you a world of time when reformatting to different journals.



General comment – top journals are allergic to the word “confirm”. “These results confirm” is pretty much a death sentence to any top level journal. The top journals see themselves as breaking new ground, with the low level journals confirming their findings. Plus, it is boring. Sure, a lot of any paper confirms previous work, but there is no need to harp on about it. Instead write about the new conclusions coming from your work. At the very least, how do your results extend the conclusions of previous papers?

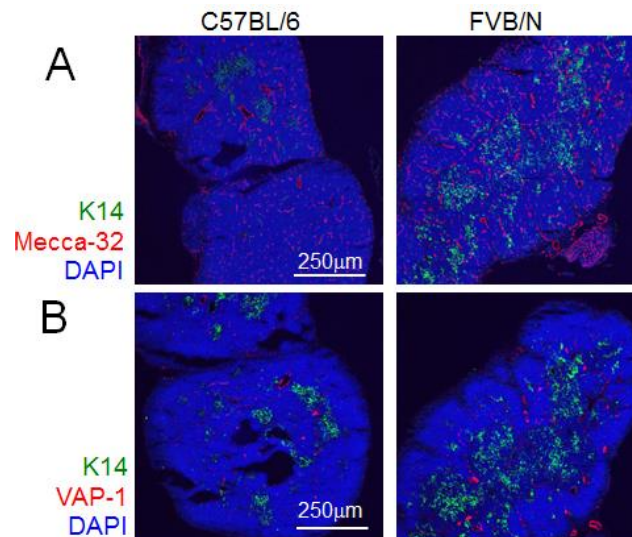
#3 tip of writing: the figures need to stand alone

For the perfect audience, a paper really comes down to one thing – the figures. The text of a manuscript (except the Methods) is really just a sales pitch to the editors and reviewers who have imperfect knowledge of the field and need to be lead to understanding the importance of your results. An expert reader will already know the background, they will be able to understand the results just by looking at the data and they will be able to integrate the results into the literature without you. For the sake of the true expert, make the figures able to stand alone, with all the information in them required to understand the results. If you are lucky enough to get a true expert as a reviewer, do not irritate them by forcing them to flick between figures/figure legends/methods and results to understand the data.

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How do you make figures stand alone? **First**, the figure legends need all the information of the experiment, including the key elements of the methods. The figure legend title should be a summary of the results from the figure legend (never the method), but the rest of the figure legend can contain all the dry repetitive material that you have removed from the results in order to aid legibility. If you use acronyms, list them here. Is the line and error bars mean plus standard deviation? Median plus standard error? List it here. Give the number of samples and whether they are biological or technical replicates. What does that * mean?

Second, the figure itself should be as self-sustaining as possible. A colour-coded key on the figure is better than a colour-coded description in the figure legend. The axes and conditions should be labeled clearly enough that it is fairly obvious what they refer to without even reading the figure legend. Scale bars should be on histology and use labels for multiple images (with, for example, genotype above each image). For immunofluorescence or the like, write the antibodies used in the colour that they are stained in next to the image. Eg:



One of the most irritating things you can do in a figure is to change the shading code from figure to figure or panel to panel. Never do this. If you use black for wildtype, white for knockout and gray for heterozygous in Figure 1, Panel A, then use the same shading code for every other figure! It makes it a lot easier for the reviewer, since they only need to look at one key once and they will understand all the figures. Likewise, if you put wildtype on the left and knockout on the right in one panel, use this for all the others (as a general rule, put your control sample on the left, it is more intuitive).

Another point to note is that a paper is not a thesis where you want as many figures as possible. Multiple panels in a single figure are fine (even 10+ panels), if they all link together into a single message (ie, the title of the figure legend / title of the results sub-section should unite all the panels). Each figure should be a substantial contribution to the manuscript, and if that requires many panels that is fine. Data that is not essential should be moved to the supplementary material (eg, repeating experiment in spleen vs lymph nodes – one can be in the main figures and the other in supplementary material). Avoid “data not shown” – this is what supplementary figures are for.

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Pro-tips for figures

- Journal-specific rules override all other rules. Sometimes they have requirements that reduce readability – c'est la vie, do whatever the journal says.
- Check the font requirements of the journal, which are frequently different between text and figures. Make sure all the text in the figure is written in the correct font and is set to the same size. This is easiest to do if you import panels without text into a program such as Illustrator or Powerpoint and then set the text font/size in that program (it also makes it easier when the plan B journal requires a different font – you can just highlight and change font rather than re-importing all the panels).
- Avoid colour unless it is needed. Think of how the paper will look when printed in black and white, which means black and white is better than red and blue, with the obvious exception of imaging work. When using colour, use CMYK not RGB, since colourblindness is quite common.
- Axes should start at 0. If they do not, the axes should not meet. Naturally, log axes cannot start at 0, and should be obvious due to the unevenly spaced minor ticks.
- The default output from Excel is ugly, but it can be used to make decent figures if you modify it. Just remove those gridlines, change the default colour scheme and font, make lines hairline point and you have something quite presentable. Imports well into Powerpoint. Note that Powerpoint “save to jpeg” gives a default of 150dpi, which needs to be changed to give publication quality images:
<http://support.microsoft.com/kb/827745>
- Prism is a nice program to use if you want to give individual data points rather than mean and error bar, but does not import well into Powerpoint. The Prism/Illustrator combination produces very high quality figures if you invest into understanding the two programs.
- Never use 3D charts and avoid pie-charts. 3D pie-charts are the worst.

#4 tip of writing: get the details right!

Scientific writing is a lot like science – getting the details right is absolutely critical. Nothing screams “unprofessional” quite like a bunch of spelling mistakes, the referral to the figures being incorrect due to an old draft (ie, saying “Figure 2b” when the data is now in Figure 3b) or your references being out of order. It is amateur and irritates both editors and reviewers. This stuff just has to be right, no excuses.



Make sure the article fits the journal format. You want the editor to think that the article would seamlessly be published in the journal without a large editorial workload. It also shows that you take this submission seriously enough to invest in journal-specific formatting (as opposed to just throwing it in to check).

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Fitting the journal format means making sure that you abide by length limits, figure/table number limits, font/spacing requirements, front-page requirements, the number of references, the order of article segments and every other minor detail of their style guide. Once you finish the review, print out the style guide and tick off every single point before submitting.

One common mistake is to use mixed US/UK English. Find out if the journal uses US English or UK English and then stick to that. If not explicitly stated on the website, look at the corporate address of the journal). Change Microsoft Word on your document to the correct form and run a spellcheck. Common scientific words that vary between US/UK are:

US: Center, Hematopoietic, Liter, Leukemia, Meter, Modeling, Signaling, Pediatric, -ize

UK: Centre, Haematopoietic, Litre, Leukaemia, Metre, Modelling, Signalling, Paediatric, -ise



#5 tip of writing: poor grammar is unprofessional

Having your paper being an easy and enjoyable read can only be a plus.

So how do you write well? That is a very difficult question to answer, as good writing is does not come naturally to anyone. Scientific papers are hampered by the need to efficiency and accurately communicate information, but there is no reason why you can't have a bit of style. In Leuven the most common sources of poor language are overly complicated sentence structure ("the Dutch sentence") and overly simplistic vocabulary.

- Sentence structure should be fairly simple. You communicate a point, then end the sentence. The next point can go in the next sentence. Do not abuse the comma, it has several important functions: to break up a sentence into discrete ideas, to make lists, and to separate out a secondary comment (often in place of brackets). Avoid semi-colons as a beginner: <http://theoatmeal.com/comics/semicolon>
- Vocabulary does not need to be simplistic. Very rarely will you hear an author praised: "oh it was a pleasure to read, she used such simple words". A well-turned phrase or the right word can really drive home a point. Consider the title "Projection of an immunological self shadow within the thymus by the aire protein". Doesn't "immunological self shadow" have a beautiful ring to it? It conjures up an image that drives the message of the paper. Much better than just writing "Genes expressed in the periphery are also expressed in the thymus by the aire protein". Using an adult vocabulary is not, however, a licence to fill your paper with jargon.
- Replace repeated words. "X regulates Y which regulates Z" sounds funny. Pull out your thesaurus and replace one of them with modulates, modifies, controls, limits, curtails or whatever.

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One general piece of advice is to ask a native English speaker to proof read your manuscript. Nothing is ever quite like the ear of a native speaker. Note, however, that most Anglophones don't teach much grammar, so the comments you get will more be "this doesn't sound quite right" than an explanation of exactly why.

Writing a paragraph

Writing a paragraph is easy, yet it is often done wrong. A paragraph needs to start with the basic premise. In the introduction this can be the topic of the background, in the results it will be the rationale for the first experiment. Then the meat of the paragraph has a series of sentences, and critically each of these sentences logically flows into the next. I often write and rewrite paragraphs, shifting the ideas around until I read a point where each idea has a logical reason for being after the preceding idea and before the following idea. Finally, a paragraph needs to have a summary sentence. This sentence envelopes the major points of the paragraph and wraps up the main theme of the paragraph in a digestible format.

A note on the passive voice: The convention of science is to write the majority of the work in the passive voice, ie "The 3A9 transgenic mouse strain was crossed to the insHEL transgenic mouse strain" (passive voice) is preferred over "We crossed the 3A9 transgenic mouse strain to the insHEL transgenic mouse strain" (active voice). Exactly why this is convention is not clear: my personal theory is that it relates to the practice of not acknowledging the contribution of technical staff to the research. Even today, some "ethics in science" classes teach students not to list technical staff as coauthors. This can make using the active voice deceptive – did the listed authors set up the mouse breeders or take the blood samples?

I recommend using the passive voice 95% of the time. I restrict the use of active voice to those times when I want to emphasize a transition from published literature to the current study. For example, at the end of the introduction the last few sentences will often start "Here we...". It creates a clear distinction that you are now talking about your results. For the rest, stick with the passive voice. It irritates a certain type of copy editor who has been trained to substitute fluent speech for stilted prose, the type who would gladly massacre the more memorable of Shakespeare's quotes, but copy editors only get their hands on your paper after it has already been accepted.

Common mistakes in grammar

Affect and effect have very different meanings. Affect means to alter ("measured whether glucose affected insulin"). If you cannot substitute "affect" for "alter" then you probably mean effect. Effect means "result", ie "the effect of glucose was an upregulation of insulin".

Access and assess have very different meanings. Access means the ability to reach ("we prevented overnight access of mice to food"), while assess means to analyse ("we assessed the role of SecA in bacterial adhesion").



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Noun-verb compounds are hyphenated, eg:

You can say, “mediated by X” or “X-mediated” but not “X mediated”. Common examples in scientific writing are:

X-binding, X-associated, X-mediated, X-dependent, X-producing

Scientific tense

Getting the tense (past, present, future) correct is extremely important for writing a polished and professional piece of scientific writing.

The quick rules of scientific tense (not 100% correct)

- The introduction is written in the present tense
- The methods is written in the past tense
- The results is written in the past tense
- The discussion is written in the present tense



The accurate rules of scientific tense

- Accurate scientific observations are considered timeless, and as such should be written in the present tense. For example, “insulin **regulates***[present]* blood glucose levels”.
- Specific scientific experiments occurred in the past, and as such should be written in the past tense. For example, “Diabetic mice **were***[past]* injected with insulin and blood glucose **was***[past]* measured”.

Each section of your paper is based on these two principles:

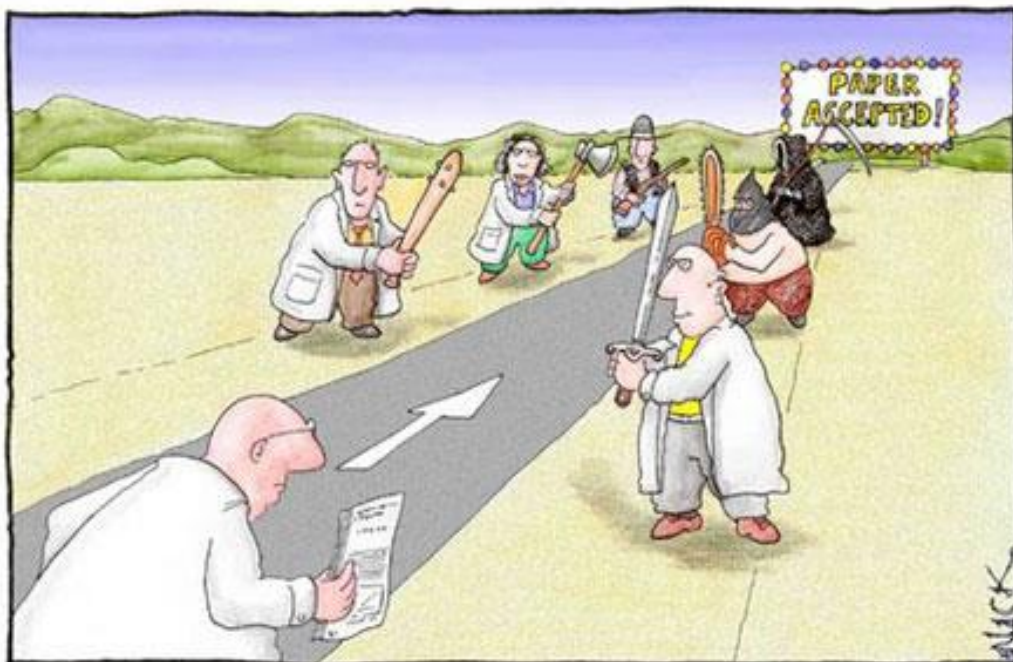
- In the introduction, you are largely going to introduce the scientific literature referring to general principles, for example, “insulin **regulates***[present]* blood glucose levels”. However sometimes you will refer to specific studies which discovered these general principles, for example, “Douglas and colleagues **demonstrated***[past]* that insulin **regulates***[present]* blood glucose levels”. More rarely, you will refer to specific studies that you consider inaccurate. In this case, the conclusions are not considered time-less, and should instead be given in the past tense. For example, “In an in vitro system, Moore et al **found***[past]* that glucose **did not***[past]* regulate insulin, however Hund and colleagues **found***[past]* that this model **does not***[present]* accurately reflect the in vivo context”.
- It is important to remember that the methods section is not a protocol (which would be written in future tense: “add PBS to the precipitate”), instead it is a description of what you did. As such, it should be almost entirely written in the past tense.
- In the results, you are mostly discussing the experiments that you performed for this paper. As such, most of the writing needs to be in the past tense. For example,

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“Insulin-deficient mice **exhibited**[*past*] defective glucose regulation (Fig. 1)”.

Occasionally, however, you will need to use mixed tense. This occurs when you are referring to general principles (which need to be in the present tense) or to purpose (which can be in future tense). For example, “As insulin-deficient mice **die**[*present*] at weaning (ref 6), we **generated**[*past*] a conditional allele to **allow**[*future*] post-weaning deletion.” Also note that referring to your figures should be done in present tense, for example “Figure 1 **shows**[*present*] the blood glucose levels in insulin-deficient mice”.

- The discussion can end up showing a mixture of tenses. When you refer to your results you use the past tense, however when you propose general principles you use the present tense. For example, “Our results on conditional insulin-deficient mice **showed**[*past*] poor glucose control, **demonstrating**[*present*] the importance of post-weaning insulin expression for glucose regulation”. As with the introduction, references to the literature should be written in present tense when discussing general principles and past tense when discussing specific experiments. Finally, proposals to future work should be written in future tense, for example “The conditional mice **generated**[*past*] here **will**[*future*] allow organ-specific deletion of insulin, such as investigations into the function of thymic expression”.



Most scientists regarded the new streamlined peer-review process as 'quite an improvement.'