Subtleties *of* Scientific Style

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Break any of these rules sooner than say anything outright barbarous.

—George Orwell, Politics and the English Language, 1946

Dedicated to Eric Corbin, who challenged accepted wisdom.

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No book happens on its own. I'd like to thank Geoff Hart and Michael Lewis for their helpful advice on an early version of this book, which saved me from many of the same errors that I criticise (except where I felt pigheaded); Rick Weisburd for sending me his improvements; Maeve O'Connor for her gracious permission to reproduce her checklist; the Canberra Society of Editors for permission to reproduce their checklist; Roger Jones for his kind permission to reproduce the ASCII character chart shown at the end of the book; Paddy and Deryck Schreuder for ideas; Dean Morris for an earlier collaboration from which I've borrowed; Flory Nye-Clement for corrections; and Linda for her encouragement.

About the author

Matthew Stevens holds a bachelor's degree in agriculture and a master's degree in extension. He became an editor by mistake when the New South Wales Department of Agriculture, flush with other people's money, offered him a job, thinking he was called Jeremy. He trained on the job under some rather clever editors, and went on to edit such classics as *Hydroponic Sheep Raising* (Agdex 430/516) and *History of Antarctic Agriculture*. After ten years there, he gave up the security of the Public Service for the uncertainties of self-employment after a well-known computer journalist advised him that e-mail-based editing would never work. He has been in business now for over 12 years, originally in partnership with his cat, and works in his home office. He is the first scientific editor outside North America to be awarded the ELS(D), the highest accreditation offered by the US-based Board of Editors in the Life Sciences (http://www.bels.org/).

Contents

About this book

This book is aimed at hands-on scientific editors, those who work with the nuts and bolts of the text—from spelling, punctuation[1] and grammar (copyediting) to meaning and logic (substantive editing). Copyeditors (subeditors) and journal editors will also find something of interest in it.

I decided to write this book when I recognised that the assortment of books on my shelves either don't mention some faults of scientific writing that I regularly encounter, or mention them only in passing. The book collects together many subtle, recurring errors that I've come to recognise in my more than 20 years of editing. It also incorporates a few essays I've written or lectures I've given on things that annoy me about scientific writing. My intention is to fill the gaps that I've found and to challenge some of the accepted wisdom of scientific writing. Many other books (see the Bibliography) cover more common or more visible problems, so I do not cover those problems here. No doubt there are others. If you have a favourite subtlety that I have not covered and would like to see it included in a later—and bigger—edition of this book, please send it to me. There are likely to be subtleties that I have not encountered or recognised, so I welcome additional ideas. Keep in mind as you read, also, that as well as a list of subtle errors, the book works as a primer in thinking critically.

You might find that some of my phraseology sounds odd or some of my "errors" are not wrong in your usage. My English is Australian, so from my perspective, much US usage is perplexing, if not wrong. Your experience of this book might well be the same. And my approach is prescriptivist.

Bear in mind that the advice given in here is my opinion, though supported by reason and authoritative references, and over 20 years' experience. If you disagree with it, that's fine, so long as your reasoning is sound too. But I think you'll find my arguments persuasive, and that you'll find reading this book as satisfying as I have found writing it.

A final word of caution: If the instructions to authors or the publisher's requirements contradict anything I say here, do what they say, no matter how ludicrous you think they are.

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1. I am not a fervent proponent of the "serial" or "Oxford" comma, so you will find here instances of where I haven't inserted a comma where you might have. Without our getting into an argument about "my parents, Ayn Rand and God", this usage reflects schooling and not logic. I can find examples of where the serial comma creates ambiguity, not solves it. But feel free to insert your own commas. Here are some spares: ,

What is science?

The word "science" comes from the Latin *scientia*, knowledge. Science is the pursuit of knowledge. It is a uniquely human activity (until we meet aliens who are similarly inclined). No other animal on Earth does it; it is a product of the human intellect.

This recognition must underlie *all* scientific reporting. *All* scientific activities are done by people. *All* scientific writing is written by people, for people. Therefore all science reflects the qualities of the people who do it and the needs of those who will be affected by it. You cannot remove the actor and pretend that the work just happened. You cannot claim that the actor is unimportant because the results would have been the same regardless of who did the experiment—conflicting results of drug trials give the lie to this belief. The convoluted passive sentences written in the third person that suggest that the work did itself obscure the reality of science. The actor is not only important, he or she is *essential*.

So when you are editing lifeless scientific prose, put the actor back in. Celebrate the pinnacle of human achievement that is science. Turn to the section on "Active versus passive voice" for an explanation of how to breathe life back into lifeless prose.

Substantive editing

The most difficult and interesting problems in editing are the substantive ones. So what is substantive editing?

Substantive editing (also known as developmental or comprehensive editing) is the editing of *substance*, not just the mechanics of writing. As with any other type of editing, its purpose is to make the work readable. It covers the basics of copyediting, including spelling, punctuation, grammar, flow, scientific conventions, style guides and appropriate vocabulary. But it goes further, covering meaning, logic, clarity, facts and correctness, consistency (internal and with the literature), coherence, completeness, structure, sequence, intended use and intended readers. It can even involve rewriting where necessary.

Jean Hollis Weber (http://www.jeanweber.com/howto/substant.htm) writes: "Substantive editing is almost entirely analysis-based, whether at the document level or at the paragraph, sentence, or word level. Decisions require judgement, not just the application of rules, and therefore should be negotiable with the writer."

The Canberra Society of Editors (1994) writes: "Substantive editing aims to ensure that the structure, content, language and style of the document are appropriate to its intended function and readership."

When editing, be sure to use your word processor's revision features, both to show what you have changed and to allow the author to undo any changes you have made. (Some authors will rightly be offended if you delete text without explanation or revision tracking.) The final content has to be the author's decision, not the editor's. (If you edit solely on paper, use sticky notes to communicate with the author, and use a different colour from the text so your changes stand out.)

Nevertheless, don't be afraid to suggest the deletion of anything that's not relevant. Saying in more words what can be said in fewer just makes the readers work harder. Good science writing is concise and gets to the point.

As a scientific editor, you have three clients: the publisher, the author and the reader. Balancing their needs can often be difficult, because they can have conflicting needs (the publisher needs to minimise cost, the author's voice needs to be retained, the reader needs an error-free report[1]). The reader is the most important. Your first responsibility is to help the reader understand the author's meaning. Your second responsibility is to help the authors say clearly what they mean without letting them look foolish. Your third responsibility is to the publisher, delivering the work within time and budget. Besides the clients, you have a final responsibility to yourself: to know that you've done a good job.

Language choice and every other writing decision depend inextricably on the combination of audience and purpose (both the author's purpose and the audience's purpose). Things that work just fine in a journal (using technical jargon) won't work well for a popular science or newspaper article. Furthermore, the author's purpose may vary even for a given audience (e.g. fellow researchers): to present just one more new but boring set of results, to review the literature without introducing any new content whatsoever, or to communicate a breakthrough in understanding. As you work, you must keep in mind the audience: What is the age of reading level? What is the reader's education? Are the readers and the author in the same discipline? Which terms need to be explained and which don't? Put yourself in the reader's shoes: Does the writing make sense? For example, *Nature* is an interdisciplinary journal. It requires authors to write for as wide an audience as possible. If an author wants to be published in *Nature*, then he or she must avoid jargon, or terms specialised to a specific field of study, and explain concepts that are not known outside that field. This emphasis on interdisciplinary communication is important in a world of increasing specialisation. For example, the mathematics of chaos applies to economics, cardiology, planetary motion and climatology. An important

1. Fast, cheap, accurate. Pick any two. For a different take, see "Cheating the quality triangle" (http://www.geoff-hart.com/resources/2001/triangle.htm).

breakthrough in one discipline will have consequences in other disciplines. Similarly, work in human genetics has implications for plant genetics, because all genes follow the same rules, regardless of organism. So readers beyond the immediate discipline must be able to understand the work. In contrast, taxonomy does not cross into other disciplines, so less explanation of concepts is called for. An understanding of the combination of audience and purpose is essential.

The substantive scientific editor needs five characteristics beyond those needed by the copyeditor:

- Critical thinking—it's not necessarily true just because a scientist wrote it.
- A logical approach—being able to follow all arguments through to their conclusion.
- Knowledge of the subject. Without this, you can't be sure whether something is true or not.
- Ability to concentrate on meaning, not just grammar.
- Consistency. This requires establishing an editorial Gestalt of a document—understanding it as a whole, not just the parts.

Steps involved

The steps listed here are based on two lists of tasks involved in substantive editing that I have borrowed (with permission) from other sources. One comes from one of the most accomplished scientific editors in the English-speaking world, Maeve O'Connor (1986, p 3). The other comes from the Canberra Society of Editors (1994). I have expanded on the original points.

Structure

Is the document complete? Are all figures and tables supplied? Is additional material or reader aids (such as figures, glossary or index) required? Has the author addressed each aim, or is information missing?

Does the document fulfil objectives? Check the instructions to authors for the publisher's objectives for the work. Does the document answer its own aims?

Is any major rewriting required? If this is not part of your brief, negotiate with the author or publisher.

Is any rearrangement, expansion or summarising of sections required to achieve the most logical structure? Should any material be relegated to an appendix or vice versa?

Content

Are language and form appropriate to the readership? Is the publication intended for a specialist audience (e.g. surgeons)? A general scientific audience (such as *Nature* readers)? A non-scientific audience (e.g. ratepayers)? Does the structure of the document lead them in a familiar way to the information? (Compare the structure of a scientific paper with that of a press release—both are appropriate to the intended audience but cannot be swapped.)

Make titles and abstracts concise, accurate, informative and consistent. In titles, avoid "studies of", delete unnecessary articles ("a", "the"), make titles into statements rather than labels. Ensure that abstracts cover the aims and main outcomes.

Add keywords and running heads (check the instructions to authors). Keywords should not repeat words in the title but instead should supplement them.

Check sections and their headings. Do the headings accurately reflect the section contents? Can you add or remove headings? Are they presented in the best order?

Examine the logic, order, correctness and emphasis of presentation. This sounds simple but can form the bulk of your work. Ask yourself as you work through a document whether it tells you (as a reader) everything that you would want to know. Can you find the information easily? Does it make sense? Are arguments presented clearly and unambiguously? Do they sit at the appropriate level?

Eliminate redundancies and irrelevancies. It is common for authors to repeat information in different parts of a document. Once is enough, unless special emphasis is required.[1] Some authors add information that interests them but bears no relevance to the work. Many authors present the same information in tables and graphs—this wastes space and creates the idea that there is some difference between the two.

Highlight contradictions. Query them if you don't know which is correct.

Suggest ways of shortening words, phrases, sentences, paragraphs. See the following sections for advice on how to reduce material: "Filler words and phrases", "Stacked nouns and adjectives", "Abbreviations", "Active versus passive voice", "Plain English in science", "Appendix 1—Editing techniques" and "Wordy phrases".

Is referencing appropriate? All statements (except "universal truths") must

1. But note: Repeating information can sometimes make text more readable, particularly in long sentences, by relieving readers of the need to retain the first part of the sentence in their heads while they read several parallel consequences that all depend on that first piece of information.

be supported by references, either published studies or presented data. Ask for clarification if support is missing. Check all references against citations (both literature and figures or tables) and ask authors to supply any that are missing.

Figures and tables

Examine tables and figures in relation to text. Do all data in the tables and figures support the points being made in the text? Are all tables and figures cited (and in order)? Are the statistics appropriate to the data and the experiment?

Ensure that table and figure titles correctly describe the contents. Go through each point in the title and look for evidence in the table or figure.

Check presentation of units in column headings and numbers in body of tables. Are all units shown in the columns? Are units SI? Are all values shown with the right number of significant digits? Are values aligned to the decimal point, or centred if of different units?

Check suitability of figures for reproduction. Can you read everything in the figure? Will readers be able to read everything when the figure is reduced for printing? Will thin lines vanish during reduction? Have authors used colour (expensive) when black and white (cheap) will do the same job? Have authors used stipples that will be indistinguishable in print? Are photos cropped to emphasize important parts? Are illustrations appropriate to the message?

Ensure that all symbols, abbreviations and terms are explained in the text or a glossary. Symbols used in figures must be explained in the figures (preferably) or captions.

Why is substantive editing important?

- Authors are under pressure to publish and don't have the time to ensure accuracy.
- Scientists usually write in jargon (language specific to their field), which may not carry the same meaning for all audiences.
- Peer reviewers can be blind to the same shortcomings as the author by being overfamiliar with the work.
- Nobody is perfect, and errors will always slip through.
- No grammar checker can ever pick up errors of logic or fact.
- Readers from non-English-speaking backgrounds also need to read and understand published science.
- Authors already understand what they're trying to communicate, and often forget that their readers don't.

Communicating with the author

Always be polite in your queries to authors. The author is probably not stupid and won't appreciate being chastised. Because it can be hard not to be terse to the point of rudeness, particularly when you're working under time pressure, take the trouble to explain yourself clearly, offer alternatives, and try to stay in the author's good books. You might have to work with that author for a long time, or you might wish to attract repeat work. Soften your comments with "perhaps", "I believe", "how about" etc. Never issue a direct order.

Nevertheless, don't be afraid to query the author on anything you don't understand. If *you* don't understand it, the chances are that someone else won't too. And don't be afraid to challenge an author. Sometimes you will know more about something than the author, or you might have read something that the author hasn't seen.

You can make your life easier by storing stock queries in your word processor as automatic text (such as provided by MS Word's Autocorrect feature), or by storing "boilerplate" text in a database. For example, I find that many authors repeat title words in the keywords list. This is normally unnecessary. So I just type the letters "kw", and MS Word automatically inserts the statement "The key words list is intended to supplement the words in the title. Therefore you can delete the words I have highlighted and add other words not in the title."

The editorial Gestalt

To do an effective job requires you to immerse yourself in the story. You need to spread your attention across all levels of the document, from word meaning to sentence meaning to overall meaning, aiming to see all levels simultaneously rather than switching between them. You need to learn and understand the story being told, and view it as a whole composed of its parts. If the parts are discordant with the whole, you will then see this. This can take effort, and is harder with longer works and with more complex studies. You are looking for evidence that the conclusions presented are supported, the facts are real and consistent, the analytical tests performed are appropriate, the statistical tests are suitable and the authors have not contradicted themselves. When you have perfected the Gestalt technique, a moment comes in a job when you think, "Yes, I understand the study." This is an important difference between substantive editing and copyediting.

A systematic approach to editing—reaching the Gestalt

Scientific editing requires intense concentration and attention to a myriad of details, from punctuation and spelling to inclusion of all details (of a reagent, for instance), to citation of references, to format, to meaning, to logic. Covering all details requires several passes of a text, in which the editor must focus first on one class of details, then switch to another. Have a look at a photo of a colourful scene. How many red objects can you pick out? Now look again and see how many blue objects you can see. You'll notice that you saw many blue items on the second pass that simply didn't register on the first pass. This is because your attention was focused on the red objects before, and excluded other colours. Editing is the same—when we focus on one class of details, we automatically exclude others. Therefore, complex editing tasks must be broken down.

Over 2+ decades, I have found the best approach through trial and error and by learning from other editors. It might work for you too. Note that it is based on the use of a word processor, although most of what I describe below can be done on paper as well.

On the **first pass**, check that everything is present—title, authors and addresses, specified sections, references, captions, figures, tables and so on. Point-by-point checking of the publisher's instructions to authors will greatly aid this process.

On the **second pass**, check the spelling. Checking the spelling up front flags the inevitable rare or non-standard spellings that require decisions. Knowing these before you start editing will allow you to ensure consistency throughout the job. It is less effective if you try to make a decision every time you come across an uncommon word while you are focused on meaning. If your word processor can check spelling constantly (MS Word: "Check spelling as you type"), then leave this feature permanently on. It will save you from introducing unnoticed errors, and the irritating red squiggles will remind you to verify any spellings you have deferred. A final spelling check is thus unnecessary.

The **third pass** is the most intensive. Start with the abstract or summary. However poorly written it is, it will set the scene for the document and allow you to grasp the intention of the work being described. It is essential to have an idea of the work up front. For readers, any document (fact or fiction) is structured to reveal meaning with the reading. Editors must know that meaning up front in order to ensure that the document reveals it appropriately. Therefore you must understand, at least vaguely, the story before you encounter it, so as to ensure that all parts work

together to convey the meaning. Spend as much time as it takes to understand and edit the abstract or summary. With the story firmly in your mind, then, you are equipped to judge whether each part of the following text substantiates the summary, and to understand how each part fits into the story.

During the third pass you concentrate on local meaning—meaning at the level of the sentence or paragraph. Are words used correctly? Can you substitute a word with a more precise or relevant meaning? Does the punctuation signal the correct meaning, or does it mislead (for example, "My brother, John" does not mean the same as "My brother John"). Can you express the meaning in fewer words or more simply (often the same thing)?

For now, take any figure, table or reference citations as read. You can ignore these supports unless you need clarification of an unclear passage. You will attend to these later.

When you reach the end, you should have a document that is easy to read. All the sentences are grammatically correct; all the spelling is correct; every text element is where it should be. It might be nonsense, but it is an elegant piece of prose. All impediments to reading for understanding have now been removed.

Now put it away if you can. Our brains process the day's learning while we sleep, during our dreaming. Numerous studies have shown that people who have slept on new information are better able to recall it than people who have not slept on it. Obviously this is not always going to be possible, but try to structure your work so that you always come back after a first edit on the following day. If you don't have time to wait till tomorrow, then try to punctuate the job with another task—another editing job, a walk, a chat over coffee. Coming back fresh, it never ceases to amaze me how many things I've stupidly missed on the first edit.

Before you put the job away for the night, though, make a **fourth pass**, checking all figure and table (or other) citations. Use the word processor's Find function to search on "fig" and "table" (or "see", "section", "supplementary", reference etc.). At the first occurrence, read the text that is relying on the citation to support it. Now go to the figure. Does it support what the text says? (A wide-screen monitor or a dual-screen set-up is invaluable for this. You can have 3 or 4 full-page documents open side-by-side and compare them quickly. It sure beats constantly switching between documents and losing one behind the other. Or you can print out the figures and tables.) It can be surprising how often the figure or table says something else, even contradictory. If you see an important point that the text does not mention, point this out to the authors in a comment—they will probably appreciate your drawing this to their attention.

Work your way figure by figure, then table by table. When you reach the end, you can be sure that when you come back tomorrow, every statement that relies on citations for support is correct (or flagged). This removes a distraction from the next stage, when you need focus on the meaning and don't need your attention distracted by having to confirm a point in another document. Whereas initially you took these statements at face value, now you know that they are correct.

During the **fifth pass** you concentrate on meaning, both local and overall. Everything you've done up until this point has prepared the document for critical analysis. All impediments to understanding have been stripped away, and the real meaning is laid bare, ready for analysis and critique.

Start again with the abstract or summary to refresh your recollection of the story. If there are discrepancies between the summary and the text, you are more likely to spot them now, because your unconscious has had time to process what you read.

The vital role of this pass is to ensure that every aspect of the text works together to create a coherent picture. Critical thinking is essential. At every statement that you read, pause and reflect on it. Is it true? Does it fit with your world experience? Is it reasonable? Is it supported somewhere? Does it support other statements elsewhere in the text, or does it contradict them? Understand it. In the words of science fiction author Robert Heinlein, "grok" it. If it doesn't gel, try again. If it's still iffy, add a comment explaining your worry.

To do this properly, you need to have created a mind space in which you hold the whole story and can turn over and examine the various parts. This is the Gestalt. When you're in it, you feel as though you're humming along in a well-oiled machine. Everything is lucid. This is why coming back with a fresh mind is important. It is also vital to understand the story, both the individual parts and their interactions. Reductionism is essential to seeing the parts. But holism is just as essential to seeing the whole.

When you are assimilating the various facts of the document, it can help to create a mental image of them. If it's a description of protein behaviour, create a mental image of proteins as they follow a schema that maps out the process. If it's a description of drug treatments to mice, picture the mice in their laboratory cages with different coloured pills raining down on them. If it's a description of how water samples were collected, picture yourself with the bucket and the sample bottles and see whether the method would work as described. If it's a description of population statistics, picture the relevant country and populate it. Whenever the text returns to a point that depends on one of these facts, it's easy to bring up the mental image again and test the new information against it. If mental imagery isn't your forte, then

draw the concepts on a scrap of paper. It doesn't matter how unrealistic your mental or graphic representations are, the point of them is to encapsulate the key points as they relate to one another (mind mapping is excellent for this), so you can compare other facts to them.

Build up the meaning piece by piece. Understand the local meanings first (such as key concepts within a sentence) then link them into a larger concept. Gradually bring these all together until you have a full picture of a passage. If you don't understand it at first, persevere. The authors understand it because they lived and breathed the study for several years, so don't expect that you should understand it all immediately. It's likely that you will have to work on the text, first to understand it, then to get it to express what the authors meant. You have correctly assimilated the information when you can take any part of a passage and see how it relates to any other part; or when you can negate one part and correctly predict the consequence if that were to happen (for instance, if you change an increase in the value of a parameter to a decrease and understand what the dependent variable would do without recourse to the figures).

Having satisfied yourself that a passage is correct, move onto the next. If you later need to revisit an earlier passage (for example, to compare with a later one or to help you understand a later concept), remind yourself that you have already verified that passage. Scan the passage for key words to refresh your memory, then use that as a support to help you understand the later passage.

This pass will be quicker than the first, you'll be looking at meaning more globally, you already understand much of the story, and you should have come back fresh, so contradictions (and confirmations) will be easier to spot this time through. In particular, you will notice any earlier statements that contradict a later statement, because you have now read the later statement, unlike in the previous pass.

At some point you must do a **sixth pass** to check references. Verify that all citations are referenced and that all references are cited (see p 86).

Finally, if you have inserted comments, do a **seventh pass** to check these. Here you will pick up any typos you made (potentially embarrassing for professionals who should know how to spell), but more importantly might be able to identify comments made redundant because you were able to clarify the meaning later.

Common errors

Many authors, regardless of linguistic background, repeat the same errors. Part of the problem is that these usages have become ingrained in the language of science, and no one thinks about what they really mean any more. They have become rhetorical signposts. As a prescriptivist, I would pass laws to ban many usages. But I can only bring them to your attention. So this section lists many of the common errors that I encounter, an analysis of why each is wanting, and suggestions of ways to correct them.

Danglers

A dangler is a phrase in a sentence (usually a participle or participial phrase) that has become orphaned and is in need of its own subject but is forced to make do with the nearest it can find (this happens in the reader's mind, of course, not on the page). The resulting problem is that the connection between the phrase and its antecedent (the thing it refers to) is lost, and even if the readers can reconstruct that connection with some head scratching, we should never force them to do that extra work. In this first example, "Wrapped in plastic" is a dangler. Grammatically it points to the wrong actor:

> Wrapped in plastic, waiting for export overseas, I get the feeling he's right.

The only subject in the entire sentence is "I" ("he" wouldn't work). So the only subject for "Wrapped in plastic" to attach to is "I". The sentence thus says that the reporter is going overseas in plastic. Not enough information is presented. To solve this problem, you need to determine who the actual actor is and make him/her/it explicit. So who or what was wrapped in plastic? This particular statement came from a reporter standing in front of a group of speedboats. (Without this visual, the sentence would have been meaningless.) Including that information makes a sensible sentence:

> *Looking at these boats* wrapped in plastic and waiting for export overseas, I get the feeling he's right.

From this revised sentence we now know what was wrapped in plastic and the fact that the reporter was looking at them. The actor is explicit.

> While paddling his kayak, the whale approached.

By not including the actor, this sentence makes it seem as though the whale

was paddling the kayak: "his" *could* refer to the whale. To get out of such silly associations, give the dangler a referent (something to refer to):

> While *John was* paddling his kayak, the whale approached.

You will find that danglers lie beneath many of the examples in a later section, "Based on", under "Tricky or misused terms", p 60.

In this next example, the dangler is "by improving", and the sentence structure implies that the annual cost is the actor:

> In India, the annual cost of providing a centralized connection of piped water to households is expected to decline more by improving the efficiency of water supply management than by reducing unaccounted for water.

What is improving the efficiency? If we reduce the sentence to its basics—"… the … cost … is expected to decline more by improving …"—we see that the grammatical structure of the sentence clearly indicates the annual cost. In fact, no one is improving the efficiency. We can fix this by :

> In India, the annual cost of providing a centralized connection of piped water to households is expected to decline more *as a result of improvements to* the efficiency of water supply management *rather* than *reductions in* unaccounted for water.

Simply by changing "by improving" to "as a result of improvements to", we have avoided the problem. (Note that this is not the same as supplying an actor to adopt the dangler.)

Here's a slightly different problem, in which "In order to" implies that the mechanism of biosynthesis had an intention:

> In order to get some possible solutions to these questions, the mechanism of biosynthesis of the simplest plant hormone, ethylene, from 1-aminocyclopropane-1-carboxylic acid (ACC) amine cation radical, was investigated.

This is a dangler, because there is no actor—no one to do the investigating. If we pare this down to its basics, we get "In order to get some possible solutions to these questions, the mechanism … was investigated. The only actor here is "the mechanism". This error is subtle, because we can read the sentence as "The mechanism was investigated." On its own that's clear. Normally, a dangler is characterised by a wrongly implied referent, rather than simply a missing one. But if we look closely, the implied referent is wrong: "In order to" implies an intention, but the only actor in the sentence is "the mechanism". The solution shows an excellent role for the first person:

> To get some possible solutions to these questions, *we investigated* the mechanism of

> biosynthesis of the simplest plant hormone, ethylene, from 1-aminocyclopropane-1-carboxylic acid (ACC) amine cation radical.

The rest are included for some practice:

> The researchers studied the phase shift of the neutrons after traversing a strong electric field.

This says that the researchers traversed the electric field. Including the referent solves the problem:

> The researchers studied the phase shift of the neutrons after sending *them* across a strong electric field.

> After three years in office, seven out of ten voters are ready to vote for someone other than Brown.

This says that seven out of ten voters have been in office for three years. We can solve this with:

> After *his* three years in office, seven out of ten voters are ready to vote for someone other than Brown.

Once you're aware of danglers, you can derive much amusement from spotting them … and can then save the authors the embarrassment of having anyone else spot them.

Filler words and phrases

Filler phrases, such as "it is known that", "it was reported that", "it is commonly believed that", are unnecessary. Get rid of them. (See "Appendix 2—Wordy phrases" on p 88 for others.) Simply make the statement, then make sure that it has supporting references. For example,

> It is known that overexpression of *DWARF* in transgenic tomato increases plant height [2].

This can be simplified to:

> Overexpression of *DWARF* in transgenic tomato increases plant height [2].

> Similar *cis*-acting elements, named C-repeat (CRT) and low-temperature-responsive element (LTRE), … , were reported to regulate cold-inducible promoters (Harker *et al*., 1993; Tian *et al*., 1995; Tomás, 1998).

The fact that they were reported is not relevant. They *do* regulate promoters (as

verified by the peer-reviewed published studies). Because the statement is supported by references, we can write this as:

> Similar *cis*-acting elements, named C-repeat (CRT) and low-temperature-responsive element (LTRE), … , regulate cold-inducible promoters (Harker *et al*., 1993; Tian *et al*., 1995; Tomás, 1998).

> It has been reported that suppression of some plant genes was caused by DNA methylation of the respective gene regions (for example, Jacobs and Mayer 1998)

is rewritten as:

> Suppression of some plant genes was caused by DNA methylation of the respective gene regions (for example, Jacobs and Mayer 1998)

Filler verbs also crop up all too often, as shown by this above example, which is a long-winded way of saying:

> Some plant genes *were suppressed* by DNA methylation of the respective gene regions (for example, Jacobs and Mayer 1998).

(We can simplify this sentence further by making the construction active, but that is not the aim of this section.) Filler verbs are verbs introduced into a sentence to cover for the unnecessary conversion of a verb to a noun.[1] Note that a perfectly serviceable verb, "suppressed", was turned into a noun, "suppression", creating a vacancy for a longer verb, "was caused by". This just adds words without adding meaning. In:

> The appointment of a permanent officer will be made,

"made" is covering for the conversion of "appointed" to "appointment". The sentence is shorter and clearer rewritten as:

> A permanent officer will be appointed.

> Sampling of plots was done in September → Plots were sampled in September.
> The next step is to embark on the formation of smaller groups → The next step is to form smaller groups.

But note that occasionally there is no elegant way to get rid of these filler verbs: "Western blot analysis of fragments was conducted …" cannot be turned into "Fragments were Western blot analysed …". We have to leave them sometimes.

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1. Calvin: "I like to verb words." Hobbes: "What?" Calvin: "I take nouns and adjectives and use them as verbs. Remember when 'access' was a thing? Now it's something you **do**. It got verbed." Calvin: "Verbing weirds language." Hobbes: "Maybe we can eventually make language a complete impediment to understanding."—Calvin & Hobbes, by Bill Watterson

Hesitancies

Many authors overdo uncertainty. They write:

> These results may suggest that the ancestral gene could have been derived by duplication.

In other words, they're not prepared to admit to anything, and probably feel that it was a bad idea to say anything at all.

Where possibility is involved, it is not necessary to use more than one qualifier or conditional. In the above example, "suggest" is enough:

> These results suggest that the ancestral gene was derived by duplication.

Otherwise it looks as though the authors really aren't sure of anything.

Where a qualitative assessment of certainty is needed, you can choose from words on the following scale: impossible, implausible, unlikely, plausible, possible, probable, likely, certain.

Misapplied modifiers

This error overlaps the shortcuts error discussed in the next section. Beware of apparently meaningful statements that, when analysed, are actually meaningless, because the modifier (adjective, adverb) is applied to the wrong word. For example, this heading:

> Genomic DNA amplification of the resistant parent

This is a subtle error. Pare away the descriptors and we get "amplification of the parent", which is obviously silly, because even the cleverest geneticists cannot amplify an organism. As a term, "genomic DNA amplification" is perfectly correct. But the authors were concatenating two incompatible ideas ("genomic DNA" as an adjectival phrase and "DNA" as a noun). What they should have written was:

> *Amplification of* the genomic DNA of the resistant parent

As you can see, it was the DNA that was being amplified, not the parent.

> Colonisation process by a fungus

This is not a process by a fungus, but colonisation by a fungus:

> Process *of* colonisation by a fungus

Or just

> Colonisation by a fungus

This next is a common error:

Correlation coefficients between X and Y

The coefficients do not occur between variables—the correlation does. Correct this to:

Coefficients of correlation between …

But, of course, "correlation coefficients for the relationship between X and Y" is correct.

This method was based on a plasmid preparation protocol from *Escherichia coli*.

But the protocol does not come from *E. coli*—the plasmids do:

This method was based on a protocol *for* preparation *of* plasmids from *Escherichia coli*.

Note that this correction is slightly longer than the original, but the meaning is correct and clear.

In order to get some possible solutions to these questions, the biosynthetic mechanism of the simplest plant hormone, ethylene, from 1-aminocyclopropane-1-carboxylic acid (ACC) amine cation radical, was investigated.

At first glance, this might seem correct. But let's pare it down to its essentials: "The … mechanism of … ethylene from ACC was investigated", which is meaningless. Rewrite (in first person) as:

To get some possible solutions to these questions, *we investigated* the *mechanism of biosynthesis* of the simplest plant hormone, ethylene, from 1-aminocyclopropane-1-carboxylic acid (ACC) amine cation radical.

As becomes clear, the authors are talking about the biosynthesis of ethylene, not the mechanism of ethylene.

Polymorphic rates between cultivars → Rates of polymorphism between cultivars

The key word is "polymorphism" (noun), not "polymorphic" (adjective).

Detection and analysis systems for microsatellite markers in wheat → Systems for detection and analysis of microsatellite markers in wheat

The following sentence is an example of misattribution:

The *in vivo* mutagenicity of DE was estimated by inhalation of DE.

If "The length was estimated by the surveyor" means "The surveyor estimated the length", then this sentence means "Inhalation of DE estimated the *in vivo* mutagenicity of DE", which is obviously silly. It should say something like:

The *in vivo* mutagenicity of DE was estimated *in a test involving* the inhalation of DE.

Information has been left out. This brings us to the next error, shortcuts.

Shortcuts (or "everyone knows what I mean")

Beware sloppy shortcuts that appear to say one thing but, on analysis, mean another.

Ears at the stage before pollination and just after heading were collected, homogenized in methanol, filtered, and evaporated to dryness.

This says that ears were evaporated, which is nonsense. Authors know what they mean, but it's your job to ensure that readers understand. Make it clear:

Ears at the stage before pollination and just after heading were collected *and* homogenized in methanol. *The homogenate* was filtered and *the filtrate was* evaporated to dryness.

Note how there are in fact three subjects here (ears, homogenate, filtrate), not one (ears).

Some weak effects of *AsWLK34* overexpression were observed on plant growth.

This sentence says that the effects were *observed on* plant growth, instead of that the authors observed *effects on* plant growth. This can be written instead as:

Some weak effects of *AsWLK34 overexpression on plant growth* were observed.

or

We observed some weak effects of *AsWLK34* overexpression on plant growth.

The point is the effects on plant growth, not, as implied, the observations *on* plant growth.

Collected samples were combined by floret status and organs, homogenized in methanol, added $^{13}C_6$-IAA as an internal standard, filtered and evaporated.

On analysis, this example explains that the samples added the IAA, and that ultimately they were filtered and evaporated (as in the earlier example). Here the shortcuts have robbed the sentence of sense. It is necessary to be clear on each point:

Collected samples were combined by floret status and organs, *and* homogenized in methanol. $^{13}C_6$-IAA *was added* as an internal standard, *then the solution was* filtered and evaporated.

The sentence is now longer than the original, with the addition of critical information, but the meaning is now clear.

How far can the inserted T-DNA activate the surrounding cDNAs?

This is a subtle example. The inserted T-DNA does not activate surrounding cDNAs by a certain distance ("how far"). As written the sentence is meaningless. Consider a singular cDNA:

> How far can the inserted T-DNA activate a cDNA?"

The implication is that the T-DNA is sending the cDNA away some distance.

The question the authors meant is:

> What is the furthest distance at which the inserted T-DNA can activate the surrounding cDNAs?

Do you appreciate the difference in implied meaning? The first sentence asks "How far can X activate Y?" The second asks ""How far *away* can X activate Y?"

Here's a another subtle error—the misattribution of purpose:

> Wild-grown *N. firma* were used to estimate the expression level of *NfHb1* in nodules, roots, leaves and stems.

This construction casts the plants as tools, in the same way as a balance might be used to estimate weight. Fortunately, the solution is simple:

> Wild-grown *N. firma* were used *in the estimation of* the expression level of *NfHb1* in nodules, roots, leaves and stems.

This rewrite takes the action away from the plants and correctly identifies it as separate. An even better rewrite would be to cast the sentence in the active voice:

> We *estimated* the expression level of *NfHb1* in nodules, roots, leaves and stems of wild-grown *N. firma*.

Shortcuts can be useful to avoid repetition of lengthy prose (see "Respectively", under "Tricky or misused terms"), but can easily obscure meaning and create silly images.

Stacked nouns and adjectives

The stacking of words, especially nouns, in long lists is common in journalese and headline writing, and rampant in scientific writing. It saves space, but that doesn't justify the guaranteed obscuration of the meaning: it introduces ambiguity (more than one possible meaning) and forces the reader to spend time interpreting it. For clear communication, it is essential to rearrange the words into a descriptive statement rather than a string of words with the same grammatical type. Here is the worst I've ever encountered (published many years ago by *New Scientist* as the winner in a competition):

> Space telescope wide-field planetary camera instrument definition team ground based charged-couple-device camera

- There are 15 words in this stack. Read the list again and stop at any noun. It could make sense, but as you read onwards to the next noun, that sense suddenly changes. If the goal is clear communication, the meaning should not change with each new word.
- Note that the word "camera" appears twice. Why?
- So what is it? What does it look like? I can't tell—can you?

As a rule of thumb, keep the stacks to three words. If pressed, use four, but never go beyond four. Here's an example (an old headline) of how extracting meaning gets progressively harder:

Two words: "bank rate". That's easy enough. Three: "bank rate rise". That's a rise in bank rates. Four: "bank rate rise leak". Now it's getting harder. Five: "bank rate rise leak probe". What's that? To get the answer we actually have to read it backwards: a probe (investigation) into the leak of a rise in bank rates.

The more words an author stacks, the harder the author makes it for the reader to keep track of everything that has been listed until the main noun arrives, and to perceive which words modify which other words and thus belong together. The reader is forced to do a juggling act, keeping not only a string of words in the air, but also their relationships between one another, which can change with the addition of each new word.

In a whole string of nouns, any of them could be the intended main noun (what linguists call the head of the nominal group). You could stop the string at any point and assume, erroneously, that you have reached the head. The longer the cluster, the more possible meanings become evident, and that's the problem.

There are three good solutions, which you can use alone or in combination:

- Unstack or rearrange the words, using prepositions: "Sheep testis growth measurement" becomes "Measurement *of* the growth *of* sheep testes".
- Turn nouns into adjectives: "testicular growth", not "testis growth".
- Hyphenate. This shows the relationship between adjectives and nouns: "left-testis diameter".

Here's another example:

> Validation of vegetation canopy lidar sub-canopy topography measurements

Without having had the benefit of editing this paper, I would not have known that this means:

> Validation of measurement of vegetation canopy and sub-canopy surfaces by lidar

In general, readers should be able to understand each sentence on its own merits rather than having to read the entire paper to get the point. Here's another example of how ambiguity is easy to achieve with stacking:

> Nine trial site soil types were recorded.

Does this mean "Nine soil types were recorded from *x* trial sites" or "*x* soil types were recorded from nine trial sites"? The author of this knew what he meant, but readers wouldn't have. In fact, it meant "soil types from nine trial sites", but it doesn't say how many soil types.

> … the WHC end function manager's technology development needs specifications

In this example, "needs" is not a verb ("the development needs some specifications"), it's a noun ("specification of needs"). This could have far more meaningfully been written as:

> … specifications *for* the technology development needs *of* the end-function manager *of* WHC

Note how the main noun, "specifications", is placed up front, giving the reader immediate knowledge of the subject. The same could have been done with the next example:

> Overall Technology Development multi-year task cost baseline estimates beginning with Fiscal Year 1994 …

which could have been written more meaningfully as:

> Overall baseline estimates *for* costs *of* tasks *over* several years *for* the Technology Development project, beginning with Fiscal Year 1994 …

To summarise: unstack, rearrange, use prepositions, create adjectives and hyphenate.

Bonus ambiguities for your amusement

These real examples collected from the Internet are included purely for amusement. If you want to rewrite them correctly for practice, then go ahead.

> She has had no rigors or shaking chills, but her husband states she was very hot in bed last night.

> When she fainted, her eyes rolled around the room.

> Patient has left his white blood cells at another hospital.

> Discharge status: Alive but without permission.

On the second day the knee was better and on the third day it had completely disappeared.

By the time he was admitted, his rapid heart had stopped, and he was feeling better.

The patient vomited a little chicken.

Golf tournament: Pfizer Withdraws Viagra As Hole-In-One Prize.

Current holdup in disposal of radioactive materials is DOE decision on plutonium waste being below economic discard limits, and DOE decision on uranium as being either scrap or waste.

Nearly five acres of migrating warbler corpses were found on the ground.

Volunteers are needed during mealtimes to assist residents who are bound to their wheelchairs.

School policy: Excused absences are sickness and death.

Federal investigators are calling on the United States to stop importing food from nations that do not meet U.S. health and safety standards, saying the Clinton administration and Congress have failed to create a system to prevent food-borne diseases in imports that may sicken and kill people.

Officials said he died of trauma suffered in the fall at a hospital across town, after being dropped off there by an unidentified woman.

Police found an unresponsive two-year old boy who had ingested cocaine during a drug raid.

UWS, Nepean provides computing laboratories for all its students, both PC and Mac ….

Product advert: Another night of sleep without snoring from your dentist.

And in April, a Florida reptile dealer, Freddy Mamba, was sentenced to 30 months in prison in a case of rare reptiles smuggled from Madagascar.

Authorities said he apparently drank himself to death at an off-campus party and bar, then returned to the fraternity where he was a pledge.

Privacy Concerns Dog Banking Industry

8th Army push bottles up Germans (a famous headline from WWII).

Errors of substance or sequence

Many authors cannot write coherently: some (usually but not always speakers of English as a second language) overestimate their language skills; others cannot write lucidly. All need guidance.

Common errors of substance or sequence are listed below. They derive from a number of sources: lack of training in written expression and logical argument, lack of instruction in preparing scientific texts, inattention to detail, late changes to the document, rushing to meet a deadline, poor planning and lack of focus.

Missing information

Authors can leave out background, explanations or data. Add a comment pointing out that more information is needed, such as "I cannot see this point in Figure 1," "Please explain why you did this" or "Where is this shown?"

Misplaced methods

Some authors introduce new methods in the Results and Discussion sections. You can shift the text to the Methods section if it forms a discrete unit, or add a comment, such as "As a method, this information belongs in Materials and Methods." Note that reports that place methods (usually called "Experimental procedures") at the end often fail to describe all methods mentioned initially in the Results. For each result, you need to confirm that the corresponding method has been mentioned.

Unsupported statements

All statements must be supported.[1] Simply say "Please provide a reference or refer to your data, a figure or a table to support this statement."

1. Except "universal truths", if it is possible to delineate these clearly. The statement "The Sun rises in the east" should offer no quibble (unless you live on Venus, which is upside down). But how do we approach statements such as "Overeating leads to obesity" or "Ninety per cent of the universe consists of dark energy"?

Unsupported findings in Abstract

It is easy to assume that the authors know what they've done, and not verify what they say in the Abstract or Summary, but occasional lapses slip through. It is necessary to verify each point presented against the main text. Where you spot an inconsistency, insert a comment like "I cannot find this result in the text. Please verify and either add that information to the text or delete this sentence." Further, Abstracts must not contain any information that is not present elsewhere in the text.

Contradictory data

The usual explanation for why a table or figure contradicts a statement is that authors have updated their data but not the text. Such errors are common. You should verify every statement against the presented data and check table sums. Often, dealing with the error simply requires changing a value in the text. But a comment is sometimes required, such as "Table 3 does not support this statement. Please check your values."

Incorrect calculations

Numbers often change during the process of review and revision, or because of rounding. Make sure that these changes are carried throughout the manuscript; for example, changes are often made in the text but not in the Abstract.

Irrelevant information

Make sure that all information that authors present is relevant to the topic. Sometimes you can suggest the deletion of irrelevant text.

Unaddressed aims

Most authors discuss their stated aims, but occasionally some don't. Usually this is because they've made late changes to the text and have not updated the aims, or because a reviewer has insisted on the deletion of some results without remembering to ask that the aim that led to these results also be deleted, but occasionally the flaw is more subtle. A close reading of the aims and results sometimes reveals that the authors believe that they have met an aim, when they have missed part of it. In all cases, a comment to the effect that "this aim is not fully met by the presented data" is warranted, usually with an explanation.

Lack of agreement between literature citations and references

Common errors include citations with no matching reference, citing the wrong paper (read the title to be sure), references with no matching citation, different years between citation and reference, spelling mistakes in authors' names, references cited by first author only when there are multiple authors, and multiple years for the same authors not distinguished by letters. Rarely will you find a perfectly prepared reference list. The use of bibliographic software, such as Endnote, can greatly reduce these problems, but few authors take advantage of such tools. (Unless authors set up Endnote properly, the maxim "garbage in, garbage out" will apply, and you're no better off.) On-line literature databases and search engines make supplying the correct details easy. But if you cannot quickly correct an error, add a comment such as "This reference is not listed in the References list. Please add it there," "This paper is not cited in the text. Please delete it or cite it in an appropriate place" or "Do you mean 1994 or 1996?" Look under "Cross-checking references by macro" on p 86 for an MS Word macro that makes it easy to hunt for all literature citations and compare them against the reference list.

Incorrect page numbers in references

Pay special attention to the order of page numbers in ranges. It's rare that authors transpose digits in page ranges, but occasionally it happens. It's very easy to miss something like "4308–4039", so develop the habit of always comparing first and last page numbers.

Sometimes references are presented with a single page number. This is usually correct, but sometimes the author has accidentally left off the other page number. A query is in order.

Issue numbers in references

Rarely, but often enough to matter, an author will list a reference with the wrong year or issue number. Normally you have no way of knowing this (short of checking every single reference in the on-line databases), but sometimes an error will stand out because the same journal is referenced several times and there is a discrepancy between years and issue numbers. For example, one reference will say 2001 and the issue number will be 49, then further down the page a reference from the same

journal will say 2004 (3 years later) and the issue number will be 53 (4 issues later). A query to the author is essential.

Lack of agreement between figures or tables and text

Many authors cite a table or figure in support of a statement, but on analysis it does not support the statement. The usual explanation is that they have updated one but forgotten to update the other. Cross-check all figure and table citations with the corresponding figures or tables. Are they all there? Do they support the referring text? Cross-check the figures and tables with their captions. Do they agree? Never blithely accept any statement by an author that might conceivably contradict a related statement elsewhere in the manuscript. You'd be amazed (or perhaps not) at how often authors contradict or misquote themselves or their data.

Errors of reasoning

We are all prone to errors of reasoning. One of the key components of substantial editing is ensuring that all arguments hold up and are supported by evidence. This section discusses a number of errors of reasoning of which you should be aware.

Anonymous authority

This is a common fallacy in scientific writing, caused by failure to cite references. ("It is commonly believed that ….") But how can you distinguish between correct and erroneous belief that something is common knowledge? This is something of a judgment call; when in doubt, recommend a citation, particularly so when the argument depends on the premise that is being assumed.

Appeal to popularity

A proposition is held to be true because influential people hold it to be true. (For many years after the discovery that *Helicobacter pylori* causes stomach ulcers, many influential doctors refused to believe it, insisting that the problem was excess stomach acid and thereby holding back the advance of treatment.) Unfortunately, this is the basis for citing the literature! However, provided the process of deriving the fact is clear and replicable (with the same result), this is the best science can do. (Science is, after all, a work in progress.) You could suggest that the author not only state the prevailing wisdom, but also point out where that wisdom doesn't answer all the questions—thus, where there is room for more research, including replication of the original results in a new context.

False or implicit assumptions

Begging the question (*petitio principii*) is the best known example of using false or implicit assumptions to support an argument. In this error of reasoning, the conclusion is based on an assumption that is itself questionable, so the proof cannot be correct by logic. A subtly different definition says that begging the question means basing an argument on the very point you are trying to prove. It is a form of **circular reasoning**. It doesn't crop up very often in scientific writing, but when it does it is easily overlooked. The result is that an author goes to print with an unsupported argument.

Begging the question should not be taken to mean "raising the question", though this is probably a lost cause.[1] When we hear on the news "The minister's attitude begs the question of his commitment to the party", it does no such thing. It merely raises or prompts the question. (Think of begging for alms and you can see how "begging" in this context is overstatement.)

The term "begging the question" is a poor translation of the Latin *petitio principii*, which literally means "claiming a principle". A better definition is "to assume the proposition".

Here are some made up examples:

> When did you start telling the truth?

This makes the assumption that you were previously lying.

> When did you stop beating your wife?

This makes the (untested) assumption that you were beating your wife.

> The Bible is the word of God because it says so.

But how do we know that it is telling the truth? Because it reports the word of God. But how do we know that it is the word of God? Because it says so. This argument can go on *ad infinitum*.

> [Some species] show greater stenotopicity [intolerance to changes in salinity] due to lesser tolerance for salinity changes.

Thus, some species show greater intolerance on account of lesser tolerance. The explanation simply restates the proposition. It doesn't explain *why* the species show greater intolerance to salinity, and comes no closer to testing the assumption.

Non sequiturs

A *non sequitur* (Latin for "it doesn't follow") is a statement that does not logically follow the statement it physically follows.

> All larvae in the tunnels were dead. Therefore the insecticide killed them.

This is not necessarily true—the larvae could have starved to death or become desiccated. In a large enough sample, there will always be natural mortality. So the conclusion does not follow logically from the previous sentence. Another form of *non sequitur* contains true statements that nevertheless do not follow logically:

> All teleosts are fish. This shark is a fish. Therefore it is a teleost.

---

1. "Give us back our eleven days!" (see http://en.wikipedia.org/wiki/Gregorian_calendar)

Statistical clumping as evidence

This is the idea that because a few unlikely events happened close together, there must be an underlying cause. ("Bad things always happen in threes.") Correlation is not causation. Where a correlation exists, the author must attempt to explain it (i.e. propose a causal mechanism), or suggest the need for further research. The occurrence of several cases of leukaemia near the Sellafield nuclear power plant in the UK is not evidence in itself that fallout from the reactor was responsible. A mechanism of action is also required.

Tautologies and pleonasms

A tautology says the same thing twice in different words; in a pleonasm, one word is implied by another. The following is a tautology:

> Species A and species B are symbiotic because they depend on each other.

The explanation ("because they depend on each other") is simply a restatement of the assertion ("species A and species B are symbiotic"). It doesn't explain *why* the species are symbiotic, or even whether symbiosis is evident.

"Vitally alive" is an example of pleonasm: "vital" means alive.

It is possible that pleonasm is as common as it is in English because of the historical influence of Norman French on the (British) court system. To ensure that all parties (English speakers and French speakers) understood a concept, terms were duplicated in both languages. Terms still used today include "will and testament", "break and enter", "cease and desist", "null and void", "terms and conditions", "without let or hindrance".

In this list of pleonasms, the redundant words are marked in italics:

at this moment *in time*
close proximity
completely full
final outcome
general public
general consensus
huddle *together*
integrated *together*
join *together*
my *personal* opinion
never *ever*
new innovation
other alternative
revert *back*
successfully refute
sufficiently enough
violent explosion
ATM *machine*
HIV *virus*
PIN *number*

Teleology and anthropomorphism

Teleology is the doctrine that the end directs the means, which is back to front. The *Concise Oxford Dictionary* describes it as "the explanation of phenomena by the purpose they serve rather than by postulated causes" and "the doctrine of design and purpose in the material world." Other dictionaries offer similar definitions. In theology, this is a valid basis of argument. In science, it is not. Scientists would never wittingly state that something exists *for* a purpose, yet many do it unwittingly, particularly in genetics and evolutionary studies. Teleology is a very subtle and insidious error of thinking and reasoning, and you as editor must be aware of the possibility. Here are three examples:

> P450 monooxygenases insert one atom of oxygen into hydrophobic molecules, to make them more reactive and water-soluble.

The explanation "to make them more reactive and water-soluble" is blandly offered as a reason for why P450 monooxygenases insert the atom of oxygen, in the same way as "to get my clothes clean" is why I put washing powder in my washing machine. In the case of the washing powder, the action is intentional (I choose to do it). In the case of the P450 monooxygenases, it is not. There is no reason or purpose involved. The P450 monooxygenases do not insert an atom of oxygen *so as* or *in order* to make the molecules more reactive. They just do it. The outcome happens to be useful for the organism. Change this simply to:

> P450 monooxygenases insert one atom of oxygen into hydrophobic molecules, *thus making* them more reactive and water-soluble.

Purpose is now absent, while consequence remains.

Note that the original sentence is also an example of **anthropomorphism**. We might think of anthropomorphism in its more recognisable form of talking animals in cartoons, or talking to our pets, but attributing intention to an inanimate object or a process, such as in the original sentence, is a more subtle form of anthropomorphism.

> However, some plants have evolved mechanisms <u>to</u> reduce the impact of photorespiration.

> However, some plants have evolved mechanisms *that* reduce the impact of photorespiration.

The original sentence says that plants intentionally evolved mechanisms. (The second is a simple solution.) This sort of construction is a very common error in

descriptions of evolution. Evolution is not directed; it is random and blind. All evolutionary scientists know this, but some still manage to commit this error. For example, in a discussion of animal evolution, an author wrote:

> What is important here is that their external structures are different as a result of their different lifestyles.

This statement is like saying "Birds have wings because they fly," which is clearly back to front. Birds fly because they have wings. Selection of the fittest, acting on individual organisms with occasional genetic alterations that are due to pure blind chance, ensures that only those organisms with useful features survive and reproduce. The others don't. Environments in which wings were useful increased the survival and thus the reproduction of birds with wings, and that's why their descendants now fly.

> What is important here is that their different lifestyles result from their different external structures.

Times smaller?

The phrase "*x* times smaller than" crops up often, in newspapers and on television, as well as in scientific texts. Unfortunately, it is usually used incorrectly.

Consider first the converse: "***x* times larger than**", because it illustrates the problem more clearly. If my cat weighs 5 kg and my dog weighs 15 kg, my dog's weight is 2 times larger than that of my cat. That's right, **2** times, not 3 times. Why? We can understand most easily if we start with "zero times larger". This means "not larger": you add the cat's weight 0 times. So "1 time larger" means "100% larger" (add the cat's weight once); so if the cat weighs 5 kg, then 100% more is another 5 kg, making a total of 10 kg. Therefore the 15-kg dog is 2 times heavier than the 5-kg cat. To put it another way, my dog is larger than my cat. How much larger? 10 kg—or 2 times the cat's weight (2 times larger). To tabulate this:

0× larger than =	no larger than =	100% (original size) =	1× the size
1× larger than =	100% more =	200% =	2× the size
2× larger than =	200% more =	300% =	3× the size
3× larger than =	300% more =	400% =	4× the size

Contrast this construction with "***x* times the size**". My 15-kg dog is 3 times the size of my 5-kg cat. Much clearer, no? The important thing to remember is that "times larger than" does not mean the same as "times". In most cases you can just change "times larger than" to "times the size of", but be sure to check the working.

As another example, if an amino acid content started at 0.01% and increased to 0.18%, it is **not** correct to write "The amino acid content in the treated plants was 18 times larger than that in the control." It **is** correct to write "The amino acid content in the treated plants was *18 times* that in the control." We could instead write "The amino acid content in the treated plants was 17 times larger than the control," but it's misleading. The key point is that a ratio of 18 is involved, not 17, and if you concentrate on the ratio, no reader will ever be misled.

Now we can tackle the "***x* times smaller than**" usage. We've all read something like "The fibre is 100 times smaller than the width of a human hair." If a human hair is 100 μm in diameter, then 100 times this is 10 000 μm or 10 mm. So the statement means that the fibre is 10 000 μm smaller than 100 μm. This is, of course, nonsense. It might not be what the author meant, but it's what the sentence says and what some readers might assume. That might not matter to many people, but to anyone communicating science, it should. After all, if you think about it, "1 time smaller" means "of zero size".

In normal discourse, we measure things in terms of their largeness, not their smallness. We say one piece of string is half as long as another, not twice as short.

When authors say "100 times smaller", they usually mean "the inverse of 100 times larger", but this is not mathematically the same. Keep in mind that although language isn't mathematics, this usage *is* mathematics.

There are various ways of rephrasing such statements:

The fibre is only 1% of the width of a human hair.

The fibre's width is 99% less than that of a human hair.

The fibre is one-hundredth [or 1/100] the width of a human hair.

The same problems arise with the constructions "***x*-fold larger than**" and "***x*-fold smaller than**". What does -fold mean? It means "in an amount multiplied by" or "multiplied by a specified number". There's a bay on the South Coast of New South Wales, Australia, called Twofold Bay; it has two large sub-bays. If you hear someone say "The problems are twofold", you know that there are two parts to the problems. But what does it mean to say "the yields increased 2-fold"? Let's start again with zero: "The yields increased zero-fold"—they didn't increase. So "the yields increased 1-fold" means they increased by 100%—they doubled. Similarly, "the yields increased 2-fold" means they increased by 200%—they tripled. This is the same pattern as for "times larger than". Such constructions are more clearly (and correctly) expressed as:

The yield increased by 100%.

The treatment yield was 2 times the control yield.

The yield doubled.

Improving expression

Scientific writing is so often dull and stodgy, and if authors have not taken care to choose the right words or to express themselves clearly, it can be misleading. This section discusses several ways you can help your authors express themselves better through consistency and conventions of clear communication.

Abbreviations

We all know the "rules" for abbreviations:

- Define them on the first mention.
- Define them only if they are used several times (e.g. at least 5 times).
- Don't abbreviate short terms (e.g. don't abbreviate postharvest to PH).
- No need to define very common abbreviations, such as DNA, AIDS, EDTA.
- No need to define SI units (e.g. m, V, A, J, kg).
- Use standard abbreviations; don't make up your own if a standard one exists.

I will add only that abbreviations should be immediately **meaningful** to the reader. Their function is to save space, but that should never be done at the expense of comprehension. A good example is given by abbreviations of numbered terms. For example, you could abbreviate "one-banded bee" and "two-banded bee" (whatever they might be) to "OBB" and "TBB", but it would be more meaningful to readers if you call them "1BB" and "2BB" (1 and 2 are unequivocal, but O and T might have many meanings) or don't abbreviate them at all. Sometimes, however, an abbreviation is so well established that there's nothing to be gained from proposing a theoretically better alternative. For example, I would prefer to see "two-spotted mite" abbreviated as "2SM", not "TSM", because "2" immediately says "two", whereas "T" could suggest many words; but "TSM" is firmly entrenched.

Associate Professor Colin Hinrichsen of the University of Tasmania wrote: "In my research work I came upon part of some computer equipment that held me up for quite a while. It was referred to in the manual as an ACD. In the circuit diagram the symbol for the ACD was a fan. You guessed it. An ACD is an air circulating device (or fan)." (*The Australian Magazine*, unidentified issue, 1994, p 50)

Similarly, the remote control for my television set has many TLAs (three-letter abbreviations), and I haven't a clue what most of them stand for. They're not *meaningful*.

The following example might hold meaning for some readers, but to most people it would be opaque:

> FSH and RH were measured by RIA and E2, extracted with RTC, purified with TLC, and measured by CPB.[1]

Your job as editor is to ensure that the intended readers will know what an abbreviation means.

If abbreviations are very similar, there is the possibility of misreading one for another. For example, you could abbreviate "lower lit stems" and "lower shaded stems" to "LLS" and "LSS". But because they differ by only one letter (and in total use only two different letters), it would be easy to read one for the other. In this case, a better discrimination would be given by "LS_{shaded}" and "LS_{lit}".

Active versus passive voice

A passive construction takes the form "something was done by someone", rather than the active "someone *did* something". A passive sentence describes something sitting around waiting to be done unto. Relentless passive sentences can make cutting-edge science lifeless, leaving no room for the human element—the people who did the science and got excited by the results.

> The passive may at times cause ambiguity by submerging responsibility for an action when a more open approach would be clearer and fairer to readers. (Snooks & Co. 2002)

An active construction makes the sentence more forceful, puts an actor in (removing the sense of things being done to) and can even use fewer words to say the same thing in a more interesting way. It also puts the actor at the beginning of the sentence, where (in English at least) it has more force.

Most passive sentences can be improved by being made active:

> Passive: The flowers were pollinated by the bees.
>
> Active: The bees *pollinated* the flowers.
>
> Passive: The wetlands were restored by Council workers.
>
> Active: Council workers *restored* the wetlands.

However, there are instances where passive is better, where the thing acted on is more important than the actor:

> The Prime Minister was run over by a car.

---

1. FSH = follicle-stimulating hormone. RH = releasing hormone. RIA = radioimmunoassay. E2 = oestradiol. RTC = rapid thermal cycling. TLC = thin-layer chromatography. CPB = charged particle beam.

Maeve O'Connor (1986) wrote: "The passive voice is correct and useful in scientific writing whenever the reader does not need to know who or what performed the action described by the verb ('The animals were fed three times a day')". It is important to keep a balance between active and passive voice. A scientific paper written entirely in the active can sound just as silly as one written entirely in the passive.

The decision of whether to use active or passive comes down to determining whether active is shorter and clearer, and whether it is necessary or helpful to identify the actor.

Singular or plural?

A **count noun** is something that is counted; for example, apples, people, cars, languages, cells, coins, atoms. Such things are counted with **integers**. A **mass noun** is something that is not counted but measured; for example, distances, times, volumes, masses, volts. Such things are measured in **real numbers**.

Real numbers are typically used in the singular (because they describe a single concept). So in science we should write the following:

one hundred grams *was* (that is, a single quantity massing 100 g)
after 30 s *elapses* (that is, a single period of 30 s)
twenty-four hours *isn't* enough in the day
9000 kJ *is* enough for anyone

but integers are used in the plural:

20 sheep *were* treated
there *were* 2×10^9 cells
Six species *are* endemic

Note, however, that in *speech*, the actual units for real numbers are plural: "0.1 grams", "1.0 metres", "2.0 amps".

Notional accord describes the agreement we choose when faced with a choice of singular or plural. Do we make the verb agree with the members of the set or with the set itself? For example, "the F_1 generation were" or "the F_1 generation was"? Notional accord describes whether we are focusing on the members ("the F_1 generation were") or the set of members as a discrete unit ("the F_1 generation was"). Either can be correct according to context.

Similarly, when discussing patients in a study, should we say "the cohort is" or "the cohort are"? The answer depends on whether you are focusing on the group as

a discrete unit (perhaps to distinguish it from another cohort; "the cohort is") or the individual members ("the cohort are"). Either can be correct depending on context.

For "number of", we can use a simple rule: "a number are", "the number is". So, "a number of cattle are" (the animals themselves), "the number of cattle is" (how many).

Note that British usage and US usage differ in relation to companies and the like. British usage treats companies (and sports teams) as plural ("British Telecom are", "the England team are"), focusing on the members of the group, whereas US usage treats them as singular ("IBM is", "the Russian volleyball team is").

Date order—avoid ambiguity

What does the date "10.11.05" mean to you? In Commonwealth countries and the US military it means the 10th day of November 2005. In the non-military USA it means the 11th day of October 2005. In China and Japan it means 5th day of November 2010. Further, in the USA, 9/11 is a date. In other places it is a fraction.

This ambiguity has no place in scientific writing. *Scientific Style and Format* (Council of Science Editors 2006) recommends only two date formats. It prefers "2005 November 10" (or "2005 Nov 10") but allows "10 November 2005". Note that both follow a logical order, of smallest to largest or vice versa. In these examples the meaning is obvious, as it is in "November 10, 2005" (but note that this order is illogical, and extra punctuation is needed). But when authors must abbreviate dates, then "10.11.05" or "10/11/05" is ambiguous and must be clarified.

In abbreviations, the only unambiguous format is "2005 Nov 10" (or "10 Nov 2005"). Some people write "2005.xi.10" ("10.xi.2005"), but this is clear only if you already know this convention.

When you are editing dates, ensure that if they do not follow *Scientific Style and Format*, they are at least unambiguous—that is, not capable of being interpreted in any way other than that intended. And if clarity is important (and it should be), then spell out the month and write the year in full.

Be aware, too, that some countries use different date systems. Our 2000 was 2543 in the Thai calendar and Heisei 12 in Japan, for example.

Exponents versus slashes

Most publishers require the use of exponents in mathematical usage. For example, $km \cdot h^{-1}$, $W \cdot m^{-2} \cdot s^{-1}$, $m^2 \cdot s^{-1} \cdot K^{-1}$. This is because using multiple slashes[1] can be

1. This is a slash: / . Also called an oblique stroke or a solidus or a virgule. So is this: ⁄ (also called a

ambiguous. For example, $W/m^2/s$ could be interpreted as either $W/m^2 \div s = W/m^2s$ or $W \div m^2/s = Ws/m^2$. The use of exponents clearly identifies the numerators (those units with a positive exponent, such as W here) and the denominators (those units with a negative exponent, such as m here).

Note, however, that there is no ambiguity with just two terms. So km/h is as clear as $km \cdot h^{-1}$.

If slashes are to be used, then parentheses can remove any ambiguity. For example, does a/b/c mean a/bc or ac/b? (Substituting numbers will make this easier to follow. What is 15/3/2? If what is meant is $15/3 \div 2$, then the solution is $5 \div 2 = 2.5$. But if what is meant is $15 \div 3/2$, then the solution is $15 \div 1.5 = 10$.) Inserting parentheses will make it clear: $(15/3)/2 = 2.5$; $15/(3/2) = 10$. And even where they are not strictly necessary (you will remember learning at school to read equivalent operators from left to right), parentheses still clarify.

First-person science

We have all read sentences like "It is concluded that Pqr1 mediates the daylength response in petunia." Or "It is thought that this result was due to contamination." But "it is thought", "it is concluded" and the like are weasel words.[1] They allow the author to slip out of the reader's grasp. The reader can't answer the question "Who thinks it?" or "Who believes it?" because the author has sidestepped the issue. Fowler (*Modern English Usage*) wrote that use of the third person "often amounts to a pusillanimous shrinking from responsibility … The person addressed has a right to know who it is that entertains a feeling he may not share or a thought he may consider mistaken, and is justly resentful of the suggestion that it exists in the void." (See also "Filler words and phrases".)

There can be many reasons why authors might use this construction:

They don't know who thinks it but don't want to admit it. This is sloppy scholarship. If a fact cannot be verified, it is no more useful than hearsay. If it's important enough to be used in an argument, then it's important enough to verify.

---

fraction slash). They are identical in meaning. The latter gives a better appearance when fractions are set with superscript and subscript: compare $^2/_3$ with $2/3$.

And while we're down here, this is a waisted decimal point: · (less precisely called a raised dot). You can use it in exponential equations to separate terms. Or you can use a thin space. The choice depends on the style guide you're using; most journals, for example, have a preference.

1. "Statements that are intentionally evasive or misleading". *Concise Oxford Dictionary*. See also *Watson's Dictionary of Weasel Words* (Watson 2004).

They can't be bothered looking it up. More sloppy scholarship.

They don't want to admit that *they* think it for fear that it won't sound important or reliable enough. This stems from the belief that "science is objective" (see below), or that their opinion doesn't count as much as someone else's.

They're unsure about the conclusion and want some wiggle room in case it turns out to be wrong. Again, sloppy scholarship. If the data are clear, then the conclusion is clear. If the data are unclear, then say so.

That's how they learned it as students. Old habits die hard, and are often passed on to the next generation.

"That's the way reputable journals do it." Maybe some do, but many don't (including *Nature*, Oxford University Press and *Behavioral Ecology*, to name a random few found in a Google search). The best example I can give is the paper that formed the foundation of all modern genetics:

> **A Structure for Deoxyribose Nucleic Acid**
>
> We wish to suggest a structure for the salt of deoxyribose nucleic acid (D.N.A.). This structure has novel features which are of considerable biological interest.
>
> A structure for nucleic acid has already been proposed by Pauling and Corey[1]. They kindly made their manuscript available to us in advance of publication. Their model consists of three intertwined chains, with the phosphates near the fibre axis, and the bases on the outside. In our opinion, this structure is unsatisfactory for two reasons:
>
> (1) We believe that the material which gives the X-ray diagrams is the salt, not the free acid. Without the acidic hydrogen atoms it is not clear what forces would hold the structure together, especially as the negatively charged phosphates near the axis will repel each other.
>
> (2) Some of the van der Waals distances appear to be too small.
>
> (Watson JD, Crick FHC. 1953. Nature 171: 737–738.)

"Because science is objective." Let's get this straight: Science is **not** objective. Perhaps the social construction theorists have gone a bit far in their analyses, but they're certainly right about one thing: science is a product of the human mind. My mind is subjective. So is yours. So is that of any scientist who formulates hypotheses, prepares tests, thinks about results and draws conclusions. Every step in the process

of science takes place in someone's mind and is subject to all the inexactnesses and the conscious and unconscious biases that are the product of that finite organ. We perceive the world through the lens of our own training and upbringing, culture, experience, beliefs, knowledge and expectations. The world might be "out there", but the only way we can interpret it is subjectively.

We can argue that a thermometer is objective. It's an inanimate object that responds according to the laws of physics to its surroundings. So if I tell you that the temperature is 25 °C, you and I have the same understanding of the temperature. Nevertheless, you might perceive it differently from me. I could say "that's pleasant," but you could say "it's hot today." Our interpretations differ. Even the assumption that temperature is important could be a bias: relative humidity might be more important.

As Albert Einstein showed with his special theory of relativity, our points of view matter. And as Niels Bohr showed us through quantum physics, even the act of observing can determine the outcome.

"OK," you might argue, "science **ought** to be objective." But if it were, it would not be science. We would call it religion, and find our truths carved in slabs of stone, immutable. Science is a process. It is an intellectual activity. Until we meet another civilisation from the stars, we have to assume that it is solely a human activity. No other species practises it; it doesn't just happen.

"Well," you persist, "should we even bother to attain objectivity?" To this the answer is a clear yes. Objectivity is like absolute zero. Just because it can never be reached is not a reason to ignore it, and cool (!) things like superconductivity can be achieved by striving. Objectivity is the unreachable, but often visible, boundary that defines our subjectivity. It is essential in science—indeed, in rational living—to acknowledge our subjectivity and the spin it puts on our interpretation of facts. We should always aim for objectivity, in the way that Buddhism aims for perfection, even though we know we can never reach it. As long as we acknowledge our subjectivity, we have a functioning science. Why? Because we can test things in different ways (triangulate) to confirm our belief, and can make the effort to explicitly state our assumptions so that we can challenge each one before we proceed.

So to come back to the reason for this diatribe, we cannot write "It is observed that …" on the basis that science is objective, because it isn't. The observer matters.

There are several reasons for writing science in the first person. By acknowledging the people involved, the author:

- makes the article more accessible to the reader (turns a one-way lecture into an implicit dialogue)

- lets the reader know exactly who did the work (the active voice is an important part of this, identifying the actor)
- takes credit for the work
- accepts responsibility for the work.

In removing themselves from the story, the authors imply that they cannot be held responsible for the work. But the corollary is that they are not responsible for any kudos—something no researcher would accept.

What about **Materials and Methods**?

Most authors I edit write the Materials and Methods section in the third person. This gives the impression that the experiments all happened by themselves. But the methods section should be a record of what *actually* happened, and should thus be written in the first person.

The general idea of the methods section is that there should be enough details to allow anyone else to repeat the work. So why are the methods not written in the second person—like a recipe? ("Add the flour and sugar, then fold in the RNA.") In fact, they are, though mainly in laboratory handbooks. In original work, the authors are reporting what they did, not an idealised version of what should have happened.

Use of the third person can make sentences longer than necessary. For example:

> Eggs were counted, larval emergence was recorded, final instars were weighed, and dates of pupal emergence were recorded.

This can be rewritten in the first person and shorted to:

> We counted eggs, recorded larval emergence, weighed final instars, and recorded dates of pupal emergence.

This gets rid of the repeated auxiliary verbs (was, were), and makes it clear who did those tasks—that it wasn't, in fact, another team, for example. To illustrate the point that it can be another team, here is a description from a plant breeding paper:

> A unique mapping population consisting of 54 chromosome segment substitution lines (CSSLs) in rye was recently developed (Smith et al., 2005). Briefly, 79 BC_1F_3 plants developed from self-pollinating BC_1F_1 (Silver/Golden//Silver) by the single-seed descent method were selected as the starting materials for development of CSSLs. Each BC_1F_3 was crossed with Silver, and then the resulting secondary F_1 (SF_1) was crossed with Silver to produce secondary BC_1F_1 (SBC_1F_1).

It could be read either way—either the authors did this or Smith et al. did it—but in this case it was Smith et al. The methods section simply summarised the previously published steps, leaving the impression that the authors repeated the steps.

I've had authors say to me "But my name's on the paper. That implies that it's my work, even though it's in the third person." Well, no. Not always. The above example is an exception. Where credit is important, use first person.

Another reason to use first person comes up where the sentence construction creates a dangler or unclear antecedent (see "Danglers" under "Common errors") or falsely attributes intention to the tools (see "Teleology and anthropomorphism" under "Errors of reasoning"):

> To test the expression of the chimeric promoter histochemically, the *Sal*I–*Xba*I fragment of the promoter was inserted into the *Hin*dIII–*Xba*I site of pBI221 …

In this example, the sentence construction implies that the *Sal*I–*Xba*I fragment had the intention of testing the expression of the promoter. Another sentence from the same paper put it much better:

> To create the chimeric promoters containing 4 or 8 copies of the enhancer-like element, *we digested* the constructs with *Xba*I …

In this case, the intention (of creating chimeric promoters) is correctly identified with the researchers, not the constructs.

So there are good reasons for using the first person even in the Materials and Methods:

- Simplifying the text.
- Explaining the rationale for a step (which is not an isolated fact but someone's conscious decision).
- Stating an expressed intention, rather than implying, through passive sentence construction, that the method did itself.
- Making it clear who actually did the work.
- Making cheating harder.

Jargon

The *Concise Oxford Dictionary* defines jargon as "words or expressions used by a particular profession or group that are difficult for others to understand". This definition implies a value judgement that jargon is inherently bad. But jargon, as the language of "a particular profession or group", allows the members to communicate concisely and to discuss concepts that simply don't exist outside their particular setting, without the need for lengthy descriptions. Jargon is desirable when it communicates more clearly than the alternative to a defined audience; it is a problem only when it is inappropriate for the audience.

Jargon can certainly be used to exclude outsiders. When a computer salesman tells you about bits and bytes and megaflops and gigahertz and cache, he is using computer jargon, which is perfectly appropriate in the computer industry, to baffle you and persuade you of the truth of his superior knowledge in the hope that you'll take his word and buy the computer whether it really meets your needs or not.

On the other hand, when a group of geneticists talk at a conference about telomeres and proteomes and homoeoboxes and PCR and sequencing, they all understand the complex concepts behind these brief labels. In this setting, jargon is inclusive, not exclusive.

The key point when you are editing is to be sure that any term—jargon or otherwise—is appropriate to the intended audience. Ask yourself (or the author) whether every single reader will understand each uncommon term. If not, can you find a more common term that says the same thing (e.g. "insect blood" instead of "haemolymph")? Or is it more appropriate to define the term at first use? Be careful, though, not to make the author look an idiot in front of his or her peers by changing standard terms to "baby" terms.

Manufacturer's details—include the country

Most scientific texts include a Materials and Methods section. The purpose of this section is to explain what was done in enough detail that readers can repeat the work. An important part of the information is the equipment and reagents used. Different models of equipment can give different results, and different reagents can cause different results. To this end, it is important to include the manufacturer's full details so the same equipment or reagent can be obtained—or so that differences in results compared with previous studies can be explained on the basis of the different experimental conditions. Most authors remember to do this (though you must check that all details, including model or batch number, are present). However, many authors routinely leave out the country, usually the USA. Why should the USA get this special treatment, when other countries are regularly identified? There's no good reason. It is not true to say that everyone knows where Wisconsin or Nebraska is,[1] or that everyone knows what the two-letter state abbreviations mean,[2] or that only

1. In 2002 the National Geographic Society commissioned a survey of American school students. It found that 11% of them could not find the *USA* on a world map, and that 69% could not find the UK (http://news.nationalgeographic.com/news/2002/11/1120_021120_GeoRoperSurvey.html). US geography is obviously not a priority in America, but it is also not a priority in other countries.

2. Consider the following US state abbreviations: MA, MB, MD, ME, MI, MN, MO, MS, MT. Can you

Americans read American journals. This is parochialism. Science is international.

For readers outside the USA (in some disciplines, easily greater than the numbers in the USA), it is not reasonable to expect them to know what US readers are expected to know—so put "USA" in and avoid potential misunderstandings. After all,

- DE is the ISO 3166 abbreviation for Germany (Deutschland)
- CO = Colombia, in South America (not the city of Columbia, in several states of the USA)
- WA is a State of Australia.

But I'm not just picking on the USA. The same is required of other countries, too. It is not enough to write just "Victoria", "Buckinghamshire", "Hokkaido", "Sicily" or "Sichuan". All readers, anywhere in the world, should be able to know the exact location and not have to guess.

Order of events

Place **methods** in strict chronological order. If anyone repeats the procedure, they can follow the methods exactly and get it right the first time. Sloppy writing often rearranges the order of events, making it unclear at first read what happened when. For example:

> Distilled water was added to the ethanol-insoluble fraction which was dried using a centrifugal dryer in vacuum, and the suspension was boiled for 4 h.

This sentence appears to describe first the addition of water to a powder, the drying of the mixture, then the boiling of a non-existent suspension. If we rearrange it, suddenly it becomes clear:

> The ethanol-insoluble fraction was dried in a centrifugal dryer in vacuum, distilled water was added, and the suspension was boiled for 4 h.

Much clearer, and shorter too. There's no chance of someone repeating the steps in the wrong order.

> Samples were ground in liquid N_2 and then suspended in buffer, after weighing.

Again, things happen in the wrong order. Change it to:

> Samples were weighed, ground in liquid N_2, and then suspended in buffer [or]

---

correctly identify them all? How long did it take you? (And who recognised that MB is in Canada?) For bonus points, what do FM, GU, MH, MP, PR and VI stand for? You can find answers at http://www.usps.com/ncsc/lookups/usps_abbreviations.html or in section 14.17 of the *Chicago Manual of Style*.

> Samples were ground in liquid N_2, weighed, and then suspended in buffer

depending on the actual order of events. (See how it can be ambiguous?)

> All distal leafy growth units and their mother growth units were carefully detached from each harvested portion (distal leafy units correspond to current-year units in deciduous species; they can be previous-year or older units in evergreen species), after their mother–daughter relationship and the positions of daughter units on the mother units (i.e., terminal or lateral) had been recorded.

Here we have to wade through 37 words (including the authors' definition of terms) before we find out that something else happened first. Then we need to do a mental reorganisation of the events we've just read about. It is a simple fix to rearrange the order:

> After their mother–daughter relationship and the positions of daughter units on the mother units (i.e., terminal or lateral) had been recorded, all distal leafy growth units and their mother growth units were carefully detached from each harvested portion (distal leafy units correspond to current-year units in deciduous species; they can be previous-year or older units in evergreen species).

Similarly, place **other events** in chronological order. For example, in the Results, describe the preliminary results that helped the authors decide reagent concentrations, then describe the results of the main experiment that was based on those concentrations. Don't describe the main results then mention, after the fact, why particular concentrations were tested.

Parallel narratives

For the sake of the reader, it is important to maintain a parallel structure in all writing. This is particularly important in science, where long sentences make keeping track of meaning a challenge.

A common example is the need to ensure that prepositions are in the right place. For example,

> 5FU/LV is still included in the current regimens, <u>either with</u> irinotecan or oxaliplatin

violates parallelism by placing the preposition ("with") in the wrong place, creating an expectation of something else to follow ("either with irinotecan or oxaliplatin or without"). There are two solutions:

> … either with irinotecan or *with* oxaliplatin
>
> … *with* either irinotecan or oxaliplatin

In both solutions, the preposition now frames the intended object: "with [irinotecan] or with [oxaliplatin]" and "with [either irinotecan or oxaliplatin]". Both constructions are parallel.

The same problem crops up frequently in scientific writing where authors discuss similar results but vary their words and sentence structure, perhaps because they believe that it is wrong to repeat words (the belief underlying the use of elegant variation[1]). Consider the following example:

> Under 665-nm light, phyB hypocotyls were more elongated than the wild type and *phyA* while *phyA* was more elongated under 700-nm light than wild type and *phyB*. Under 690-nm light, *phyB* and *phyA* hypocotyls were more elongated than the wild type.

This example shows varied word order. However, varying the word order can give the false impression that there is some difference in the meaning of the sentences, one that in fact doesn't exist. This can be confusing, leading readers to expect that different situations are being discussed, when in fact the situations are the same in each instance. See how the information could have been much more clearly expressed:

> Under 665-nm light, phyB hypocotyls were more elongated than the wild type and *phyA*. Under 690-nm light, *phyB* and *phyA* hypocotyls were more elongated than the wild type. Under 700-nm light, *phyA* hypocotyls were more elongated than the wild type and *phyB*.

The information is now presented in parallel—the same concepts are presented in the same place in the same order, allowing readers to compare them quickly. There is no suggestion that different concepts are being stated. Note that the sentence order was rearranged, as well as the word order in the "700-nm" sentence. Placing concepts in a predictable order helps readers follow the argument better, because the subject is not jumping back and forth.

Repetition of the same words in the same place or order is important. Consider:

> In the control, weights increased to 10.3 g from 8.7 g, and from 8.6 g to 18.2 g in the high treatment.

This example, where parallelism is inverted, reverses the order of events. When presenting "from–to" results, *always* follow the order "*from* X *to* Y", never the other

1. The use of different words for the same thing so as to avoid repetition. See Fowler's *Modern English Usage*.

way around, because the word order mimics and reiterates the event order.[1] (The sentence structure thus becomes transparent, allowing the meaning to show through clearly.) By switching around the order of events, the sentence above gives the false impression of parallelism between 10.3 g and 8.6 g and between 8.7 g and 18.2 g. It also puts the treatment name in a different place, giving the impression on first reading that the second weight increase occurred in the control too. An appropriate rewrite is as follows:

> Weights increased *from* 8.7 g *to* 10.3 g in the control, and *from* 8.6 g *to* 18.2 g in the high treatment.

This restructuring highlights the words that differ, pushing them to the front of the reader's attention, and pushing the repeated words to the background. Remember that scientific writing is not intended to be literature. It should be a concise presentation of the facts.

Another important use of parallel narrative occurs in the use of the simple words such as prepositions, articles and verbs. We can often find a sentence in the newspaper like:

> She was carrying a helmet, black bag, potted plant and wearing a red cape.

If we break this up into a list, in which the introductory phrase ("She was carrying") points to each item in turn, we can see the problem:

> She was carrying a
>
> - helmet
> - black bag
> - potted plant
> - wearing a red cape.

So "she was carrying a wearing a red cape". The verbal markers are missing, causing the reader to stumble, because what was indicated (by the commas in this case) is not what was meant. Put the markers in, repeat the articles and repeat the auxiliary verb (to reinforce the parallelism), and we have a comprehensible sentence with a parallel structure:

> She was carrying a helmet, *a* black bag *and a* potted plant and *was* wearing a red cape.

---

1. A related problem occurs when authors write "The control increased by 8.7 g to 10.3 g." Does this mean "The control increased *from* 1.6 g to 10.3 g" or "The control increased *from x* g by somewhere between 8.7 g and 10.3 g"? The meanings are very different. Be aware of this trap.

Plain English in science

I have had scientists say to me that they don't have to write in the style we call plain English.[1] They are exempt.

This is, of course, nonsense.

Why should authors worry about plain English in scientific writing? Because they have readers. Unless they are writing solely for themselves, they must always consider the readers. It is our job as editors to help them achieve that.

It is important to remember that the readership might include people who are not familiar with the subject area. For a start, even experts in a subject sometimes read to learn something new. But more broadly, there are students entering a discipline, researchers in other disciplines, policy makers and interested amateurs. All these people should be able to understand what they read.

In science written for lay readers, plain English is essential. But even scientists can benefit, where the aim has been to write clearly, not just to simplify. After all, jargon is essential when scientists communicate with other scientists (when one word communicates more clearly than a lengthy description). Obfuscation is the enemy.

One of the fundamental features of science is the furtherance of knowledge. Poor writing is an impediment to this. A good illustration of this point is a paper by Oswald Avery, Colin MacLeod and Maclyn McCarty published in 1944 in the *Journal of Experimental Medicine*, which established that DNA was the substance that transmitted genetic information. Although it paved the way for James Watson and Francis Crick's milestone paper in 1953 in *Nature* (171: 737–738) establishing the structure of DNA, it was not widely read or appreciated. Author Randy Moore has argued that the way it was written was the main reason for this (*Journal of College Science Teaching* 1994 November: 114–121). In comparison with Watson and Crick's paper, it is (as Moore wrote) hesitant, extremely dense, verbose, highly detailed, abstract, impersonal and dull. We've all heard of Watson and Crick. Who has heard of Avery, MacLeod and McCarty?

The *Journal of Natural Resources and Life Sciences Education* (1993; 22(2): 198–199) puts it well:

> The author and his or her closest colleagues will be the only people who read a truly murky piece of writing …. A truly outstanding piece of writing will be widely read, widely quoted and cited, and will bring great rewards to its writer …

1. "… clear, straightforward expression, using only as many words as are necessary. It is language that avoids obscurity, inflated vocabulary and convoluted sentence construction."—Eagleson (1990)

> The secret of producing an outstanding piece of writing is to always keep the reader in mind. Authors who keep readers in mind convey their information more lucidly than authors who write only for themselves. The scientist who has the attitude, 'Why should I worry about how this is presented; everybody *knows* what I mean,' is incorrect; everybody does *not* know.

Unfortunately, much scientific writing obscures the message by using fancy words, long sentences, flowery prose, convoluted phrases, poor grammar, passive sentence construction, copious abbreviations, unnecessary words and waffle. As editors, our responsibility to the readers requires us to persuade the author to remove these impediments to clear understanding.

Authors will benefit too:

- Ultimately they will save time because journals will ask for fewer corrections.
- They will earn greater respect from their readers if they show that they have taken the trouble to express themselves clearly.
- They will have fewer rejections from funding bodies and consequently more funding.
- They will gain a better understanding of their own work. As Albert Einstein once said, "If you can't explain it to an eight-year-old, you don't understand it."
- Their work will be read more widely.

As Quintilian, a Roman rhetorician (AD 35–100), wrote, "One should not aim at being *possible* to understand but at being *impossible* to *mis*understand."

Position of adverbs

The position of adverbs can determine the meaning of a sentence. The best example is the placement of "only". Read the following sentences, which differ only (!) in the placement of "only", and see how the meaning changes:

> **Only** my cousin knits pink jumpers. (No one else knits them.)
> My **only** cousin knits pink jumpers. (I have only one cousin.)
> My cousin **only** knits pink jumpers. (She doesn't sell them.)
> My cousin knits **only** pink jumpers. (She doesn't knit blue jumpers.)
> My cousin knits pink-**only** jumpers. (She doesn't mix colours.)
> My cousin knits pink jumpers **only**. (Not pink bootees.)

In writing, particularly scientific writing, word order matters more than in speech. This is because in speech we have gestures and vocal emphasis at our disposal, as well as the words, and we get immediate feedback from our listeners, allowing us to modify our message as we go. In writing, we have only words, and

there is no feedback. So if we want our readers to understand our writing on first reading, then we must pay attention to word order.

In this "only" example, most of us would say "My cousin only knits *pink* jumpers" if we were saying that she doesn't knit blue jumpers, and we would put the vocal emphasis on "pink", raising both our pitch and our volume slightly. Read the following similar examples out loud:

I only like butter cake.

She only reads fiction.

The Prime Minister only listens to his favourites.

In each case, where did you put the emphasis? On "butter", "fiction" and "favourites"? And you de-emphasised "only"? No one listening to you would mistake your meaning. But in writing, alternative interpretations are possible. The second example, for instance, could imply "She doesn't *write* fiction, she only *reads* it". In speech, we would emphasise "reads" or "writes", as appropriate. But we don't have this capacity in writing, being limited to italics and punctuation, which are not as subtle as vocal pitch.

The same argument applies to other adverbs, too. For example:

Imperfect clones were mostly contained in library D.

This could, conceivably, be interpreted to imply "But some clones were *imprisoned* in library D", though we'd be silly to read this meaning into the sentence, of course. Nevertheless, see how the sentence is strengthened by repositioning the adverb:

Imperfect clones were contained *mostly* in library D.

If we spoke the original sentence, we would emphasise "mostly", making the meaning clear. But in the rewritten version, the emphasis is placed naturally on "mostly".

An alternative solution comes from deleting every non-essential adverb. Far from strengthening prose, adverbs can weaken it. We can convert the adverb into an adjective, removing the ambiguity in the meaning of "mostly" that can result from regional idiom in the placement of adverbs:

Most imperfect clones were contained in library D.

We could even ask for the qualitative meaning to be quantified:

Ninety per cent of imperfect clones were contained in library D.

Adverbs have a natural place in English, though this can vary with idiom.[1] The

1. English is annoying in having so many exceptions to all its rules. This is where you need to develop a good ear and not stick slavishly to the rules.

Concise Oxford Dictionary explains (10th ed, p 1686):

> The position of adverbs in phrases and clauses follows fairly clear rules, i.e. they normally come between the subject and its verb, or between an auxiliary and its main verb.

For example:

> We quickly froze the samples. (Between subject and verb.)
> The rats were painlessly euthanized. (Between auxiliary and main verb.)

I'd like to concentrate on this second situation. Writers will sometimes alter this order, putting the adverb up front:

> The rats painlessly were euthanized.

If this is an author's wish, then let it stand. It's not grammatically wrong. However, it can make for clumsy sentences, and can sometimes alter the meaning. For example:

> The protocol was always followed carefully.
> The protocol always was followed carefully.

There's a subtle difference. The first sentence tells us that the authors always followed the protocol. The second shifts the emphasis onto "was", connoting a very long-term trial in the historical past. (Like in the sentence "Lord Melbourne always was a favourite of the Queen.") Try saying it out loud, putting the emphasis on "was" in the second sentence. Can you hear the difference?[1] Another example:

> *Betula glauca* is also frequent in mountainous areas.
> *Betula glauca* also is frequent in mountainous areas.

The first sentence tells us that as well as being frequent in lowland areas, *B. glauca* is frequent in mountainous areas. The second sentence tells us that another species is frequent in mountainous areas, and *B. glauca* is frequent there as well. As this shows, this shift of emphasis can be subtle but important in the right place.

> The instrument sometimes was difficult to calibrate. (Confirming suspicions that it might have been.)
> The instrument was sometimes difficult to calibrate. (But mostly it was fine.)

But in most cases the "natural" word order is preferable. This natural word order also extends to "split infinitives" (an outmoded principle of style based on a false understanding of grammar). It is perfectly good English to write "to boldly go".

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1. In the sense of "always used to be" but isn't any more because he's dead. This is not the same as "Lord Melbourne was *always* a favourite of the Queen", which emphasises the permanence of his standing, not the past nature of her feelings.

Be aware also that, although adverbs always modify a verb, they can sometimes have an association with ideas. Placement of an adverb can emphasise one idea over another. Compare the meanings implicit in the next two sentences (where "more or less" has an adverbial function):

Such variation was synchronized *more or less* among branches.

Such variation was *more or less* synchronized among branches.

The first suggests that although variation was synchronised among branches, some variation was synchronised among other organs. ("More or less" associates with "among branches".) The second suggests that synchronisation was pretty much complete. ("More or less" associates with "synchronized".) However, these meanings are not explicit; they depend on the reader's interpretation. This shows a good reason to remove adverbs or to qualify their intended meaning.

Here's another example of where adverb placement can have subtle but important effect on meaning:

The formation of axillary buds normally occurred.

The formation of axillary buds occurred normally.

The first wording indicates that axillary buds were formed in most cases. The second indicates that the axillary buds, when they were formed, looked normal, not malformed. Become attuned to adverb placement, because it can have an important effect on the meaning that the reader takes.

Put subject and verb at the front of long sentences

A common practice in scientific writing is to write a great long string of items before finally explaining their purpose or what happened to them. This is unfair to readers, who have to wade through several lines, keeping all those words in the air before being told how to process them. The following sentence is a good example:

Using these lines, the QTLs related to agronomic traits such as heading date (Brown *et al.*, 1998; Green *et al.*, 2005), ripening (Black *et al.*, 2002), and grain size (White *et al.*, 2002) or those related to physiological traits such as tolerances of excess Al (Gray *et al.*, 2002) and P deficiency (Gold *et al.*, 1998) have been identified.

That's four lines containing 29 words and five references before the reader is told what happened to the QTLs. Notice that this sentence is written in the passive form—there is no actor controlling the action—and contains a dangler. Now see how it changes when we turn it into an active sentence, which is also written in the first person:

> Using these lines, *we have identified* the QTLs related to agronomic traits such as heading date (Brown *et al.*, 1998; Green *et al.*, 2005), ripening (Black *et al.*, 2002), and grain size (White *et al.*, 2002) or those related to physiological traits such as tolerances of excess Al (Gray *et al.*, 2002) and P deficiency (Gold *et al.*, 1998).

See how it now tells you immediately what happened? There's no need to suspend processing of all the words until you find out how to process them: the reader knows right from the start that everything in the sentence is something the authors identified, rather than having to reach the end of the sentence to find out why the author is mentioning all these traits.

As I discuss in the sections on "Using" and "Danglers", the original sentence imputes the action of "using these lines" to the QTLs. So the rewrite also removes that error and correctly attributes the action to the authors.

> The results of a socio-economic survey of farming systems practising rice culture with introduced fish, rice culture with indigenous fish and rice monoculture in the semi-deep waters of the Mekong Delta, Vietnam, are presented.

Again, you are required to suspend all these words and their possible fates until right at the end. Simply placing the verb up the front and making the sentence active makes it much easier to assimilate:

> *This paper presents* the results of a socio-economic survey of farming systems practising rice culture with introduced fish, rice culture with indigenous fish and rice monoculture in the semi-deep waters of the Mekong Delta, Vietnam.

(There is no problem with attributing the presentation to an inanimate object. Nobody would believe for an instant that the paper is controlling a slide projector.)

Symbols

Many people don't know how to type special symbols (such as mathematical symbols) on the computer, and so use substitutes. A common substitute is x (the letter) for × (the multiplication sign). You can improve the readability of a text by correcting such substitutions. This also improves the scientific accuracy of the text and the final appearance. As you can see in the table here, the differences can be significant, particularly if formatting is lost.

Most common symbols are available in the Symbol font; some, such as μ and ±, exist also in the standard base font. (Note, though, that there are some differences between Mac and Windows fonts.) Problems can arise during the automated typesetting that is the norm these days, when a non-standard character

gets substituted with something entirely different. This makes sticking to standard symbols (and fonts) important.

Always check the publisher's guidelines before you make any changes. Some publishers specifically forbid the use of the Symbol font; others insist on it. If this is the case, the safest approach is to fudge the symbols (as in the table here) and mark them so that the journal staff will see them and convert them. Similarly, some publishers request the use of equation-editor software such as that in Word, whereas others forbid it. If part of your responsibility is to include the correct symbols, rather than leaving this to the publisher, make sure you understand what the publisher wants you to do.

Symbol	Fudge	Comments
×	x	In equations, x can be confused with the variable *x*
·	.	Use the waisted (or raised) decimal point instead of a full point (full stop or period) in chemical formulae and mathematical expressions
°	∘ 0 º °	Look out for superscripted o or 0, masculine ordinal[1] and ring diacritic[1] in place of the degree symbol. If the superscript is lost, you get an o or a 0
–	- --	En rule or en dash (in number ranges or linked concepts)
—	- ---	Em rule or em dash (as a separating dash)
′ ″	' '' ' " ´	Minutes and seconds, not quotation marks or acute diacritic
≤ ≥	≤ ≥	Use proper symbols, not underlines (which can be lost, leaving < >)
μ	u	Use mu, not u (but from the standard font, not a different font)
±	±	Use proper symbol, not underline (which can be lost, leaving +)
β	ß	β is the Greek letter beta. ß is the German double-letter "ss"[2]
‘ ’ “ ”	' "	For punctuation, use typographic quotes, not typewriter quotes

1. The masculine ordinal is used on numbers in Romance languages; e.g. 3º = 3rd. The ring diacritic is used in Scandinavian languages, among others, to make Åå and other combinations.

2. This is the *Esszett* or the *Scharfes-s*. It is formed from the mediaeval form of the letter s, ſ, and the mediaeval form of the letter z, ȝ.

For lists of common characters available both on Macintosh and in Windows, turn to Appendix 5, p 93.

Yes, we have no inflections—a plea for commas

Most European languages retain inflections on words—endings that indicate the function of the word in the sentence, whether as verb, nominative case, accusative

case, adjective or whatever. Russian and Latin are good examples of highly inflected languages, in which the identification of a word's role in a sentence by its ending makes for very flexible word order. But simplicity is slowly prevailing, and most modern European languages have lost much of their inflections. English retains some inflections: -s to indicate plurals, -ing to indicate present participle, -ed to indicate past participle, and a few others. But among nouns, we have lost all forms of case inflections, with the exception of the genitive case ("'s").

Case is the role of a noun (or noun substitute) in a sentence. In English some authorities recognise five cases: nominative ("*the dog* barks"), accusative ("I hear *the dog*"), genitive ("the bark *of the dog*", or "the *dog's* bark"), dative ("I gave *the dog* a bone") and vocative ("Be quiet, *dog*!"). Only the genitive case (indicating possession or association) retains an inflection ("'s").

To indicate the role or relationship of nouns in sentences, modern European languages use **prepositions**, such as "in", "of", "to" and "from". This is a much simpler system, and allows us to make do with a single form of a word in nearly all situations, defined by one of a handful of prepositions.

But this can also lead to ambiguity. The absence of noun inflections masks the role of a noun in a sentence, making the use of punctuation and prepositions more important in English than in highly inflected languages. On first reading,

> The sample was placed in the vial and the dye, which was supplied by XYZ Inc., …

can be read as meaning

> The sample was placed in the vial and <u>in</u> the dye, which was supplied by XYZ Inc., ...

A simple comma resolves any ambiguity and avoids the need to reread:

> The sample was added to the vial, and the dye, which was supplied by XYZ Inc, …

The omission of a comma before a conjunction that marks a new phrase is common practice in journalism, perhaps because of the need to save space, but in science, where clarity is paramount, commas can perform a vital function. Anywhere you could delete the "and" (or "but") and start a new sentence, the comma is valid.

On the other hand, if the "and" really does imply linkage of concepts ("in the vial and in the dye"), then repeat the preposition to show that the reading is correct:

> Samples were collected from the treatment animals and *from* the controls.

It is common practice in English to omit prepositions in series of noun objects with the same relationship to the noun actor, but where ambiguity is possible, it is both correct and desirable to repeat them.

Improving visual presentation

Part of the subtlety of scientific editing lies in knowing the tricks of presenting visual information, notably tables and graphs, in ways that maximise readability and information transfer. This section discusses various ways you can help authors improve their graphics.

Graphics in word processor files—don't!

The word processor is not a graphics program. The positions of elements in graphics drawn in MS Word, in particular, can change unpredictably from computer to computer and from time to time, and text can expand to overflow text boxes. Publishers will not accept illustrations drawn in word processors because of these risks of changes (what they see might not be what the author sees); because images can be difficult—sometimes impossible—to extract in order to put them into a publication; and because the drawing options are limited and the results often appear clumsy and amateurish.

Advise authors that before they submit their work, they should redraw embedded illustrations in a professional drawing program, such as Adobe Illustrator, Macromedia FreeHand, Corel Draw or Deneba Canvas. The format should be EPS, TIFF or PDF, to ensure guaranteed compatibility with the publisher's typesetting software. Most publishers will not accept anything prepared in PowerPoint or Microsoft Publisher. Graphs created in Excel are usually OK.

Preparing graphics

Most publishers take graphics as presented by authors and reproduce them exactly as submitted, with no editing. So it is important that all graphics be correct in all aspects. A poor graphic will reflect badly on an author's work (and on you as editor). You need to advise authors on how to make their graphics conform with the publisher's requirements. These could include typeface, type size, type weight, presentation of units, shading, or placement of labels. Check all spelling too.

Because graphics are reduced to fit into the standard column widths, the details and text must be legible at the final size. Advise the author to check that the graphics are still readable at the final size, and that rules have not disappeared.

Computer graphics come in two formats: vector and raster. A **vector**, as in maths, describes the movement of a point in space. Graphics drawn by vector look

good at any size, taking their maximum resolution from the resolution of the display medium (computer screen, paper, photograph etc.). EPS (Encapsulated PostScript) and PDF (Portable Document Format) files encode vector graphics, as do PICT (Mac) and WMF (Windows Metafile).

Raster is the format used by all television screens and computer monitors: the image is built up from a series of dots. If you enlarge the image, you simply enlarge the dots. There must be enough dots so that in the final reproduction, they remain small enough not to be apparent. The resolution of the image is expressed as the number of dots per linear measure (such as dots per inch [dpi] or lines per mm). TIFF (tagged image file format) and BMP (bitmap) files encode raster images.

If the author provides vector graphics, this is good. You can be sure that the final image will look the best it possibly can, regardless of the size or medium. But if the author provides raster images, they must have a minimum resolution, or the printed image will look dreadful. A typical minimum resolution is 600 dpi, but check the publisher's requirements.

If the author intends to submit hard-copy images (such as photographic prints), the same requirements for resolution apply. Photocopies are rarely acceptable, because they tend to lose detail. Hand-drawn images are acceptable if they use dense black ink. Shading must not be so fine as to cause detail to drop out during reproduction. Letraset transfers offer excellent stipples and rules.

If authors use colour when it is not necessary to the message, advise them to use black and white with shading. Colour reproduction is much more expensive than black and white, and authors will usually be asked to pay for the colour. On the other hand, if a black and white image does not convey the message, suggest the use of colour (with a warning about possible cost).

If authors plan to submit digital colour images, advise them to prepare the images in CMYK (cyan, magenta, yellow, black) format, not RGB (red, green, blue). The publisher will convert an RGB image to CMYK, but the colours *will* change. If colour is critical, crucial information could be lost.

Excellent advice on preparing graphics is provided on **Springer's** Web site: http://www.springeronline.com/. Click on [Our services for] Authors, then click on Artwork Guidelines. (I haven't provided the direct link because these things change.) You can also go to **Blackwell's** Web site: http://www.blackwellpublishing.com/ and click on the Resources menu and select For Authors from the pop-up list. On the next page, click on Preparing Illustrations (under Book Author Services). For advice on electronic file formats, click instead on Author Resources (under Journal Author Services) and then click on Illustration Submission Guidelines.

Consistency in figures

When you check figures, ensure that authors have used the same symbols, hatches or colours for the same things throughout all figures. Using different representations in different figures can create false impressions; for example, if the reader has learned to recognize red as referring to males, suddenly using red to denote females will lead many readers to assume that it relates to males instead. As a reader, having understood the correspondence between colours and variables in one figure, you should expect to be able to read all other figures the same way, and not have to switch from figure to figure.

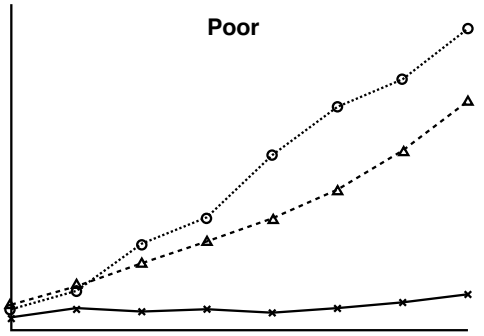

Figure 1a. Treatment of hydroponic sheep with growth hormone. Crosses: control; triangles: low dose; circles: high dose.

Keys in figures

Encourage authors to place all visual information pertaining to figures *in* the figures, not in the captions (never *describe* symbols), and not in a separate key if it can be helped. As you can see in Figure 1c, putting it all in the one place makes for easier interpretation by readers; not only is it unnecessary for the reader to glance back and forth between the caption and the image, it's also the only way to ensure that the symbols are produced correctly by the publisher (symbols used in the caption in the word processor file can be lost or changed during automated processing by the publisher). The labels in Figure 1c directly identify the curves. The reader does not have to go from place to place, matching up symbols. The caption is simplified too. This is the best presentation.

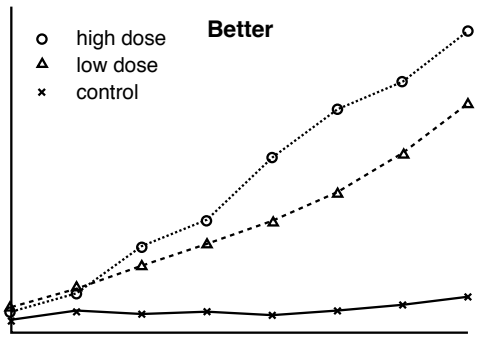

Figure 1b. Treatment of hydroponic sheep with growth hormone.

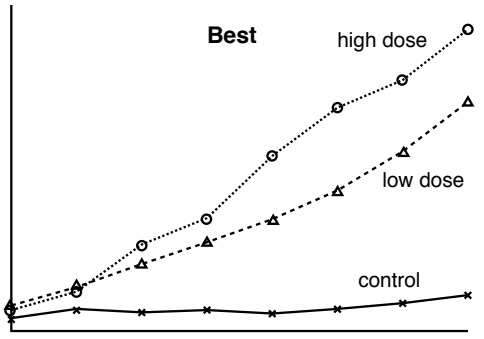

Figure 1c. Treatment of hydroponic sheep with growth hormone.

If the use of a key is necessary, ensure that the variables in the key follow the

same sequence as the curves, as shown in Figure 1b. It is disorientating when the key lists variables from top to bottom while the graph displays them from bottom to top. However, if the order of the curves varies from graph to graph in a series of graphs, it may be more effective to use the same order of symbols in each graph. Understanding whether this is needed requires you to put yourself in the reader's position and actually try to use the graph: if you find consistent symbol order more helpful, use that order instead. But try to label each curve if there is space (Figure 1c). This avoids all toing and froing.

Zero point in graphs

Except in logarithmic graphs, where zero is mathematically impossible, the zero-point should always be marked on both axes. The reason is that we process graphs visually, not logically.[1] Look at the two graphs in Figure 2.

At first glance they look the same. The trend they describe seems to be the same. But notice that the *y*-axis of the graph in Figure 2b starts at 50, not 0. This can mislead readers, particularly in a side-by-side comparison such as this one. For the same reasons, encourage authors to use the same scales for graphs that show the same thing, to allow visual comparison. It is no help to have three graphs all neatly the same height (say, 20 mm) but covering very different ranges (say, 0–20, 0–100 and 50–150). They cannot easily be compared. See Figure 3 for an idea.

Think of the graphs you see in the newspapers or on the news describing interest rates or trade deficits (see Figure 4a for an example). They are drawn to highlight the short-term variation, at the expense of the longer-term context in which that variation occurs. They can seem to indicate that the exchange rate, for example, has plummeted in the past week, when in fact it has dropped only 1%. Careful choice

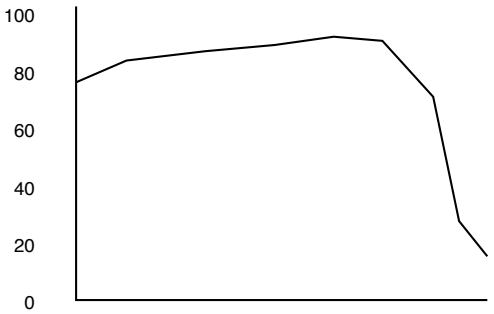

Figure 2a. Survival of hydroponic sheep in water.

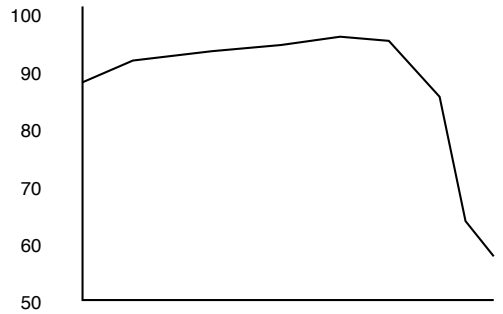

Figure 2b. Survival of hydroponic sheep in air.

1. For the last word on clear presentation of visual information, read the work of Edward Tufte at http://www.edwardtufte.com/tufte/

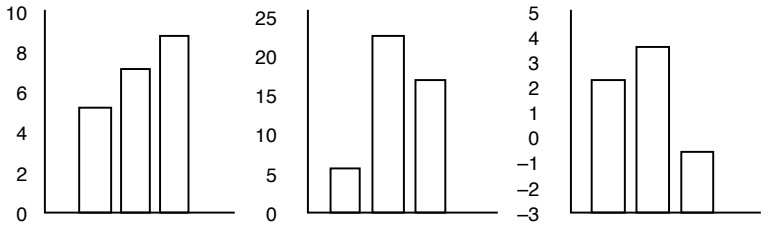

Figure 3. Three graphs that can't be easily compared.

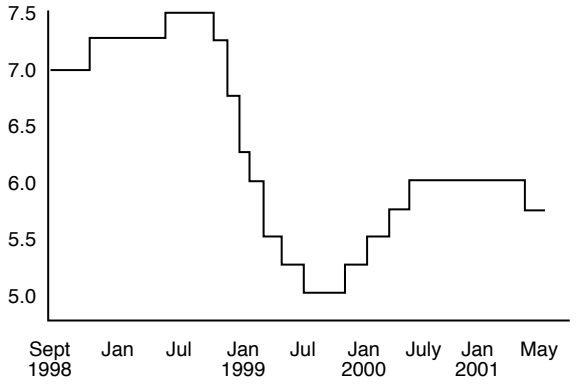

Figure 4a. This graph makes it look as though the interest rate nearly collapsed in July 1999. But it actually dropped by less than half.

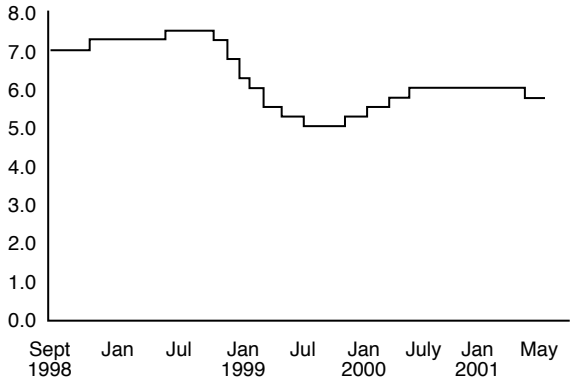

Figure 4b. This graph shows it in correct proportion. No crisis.

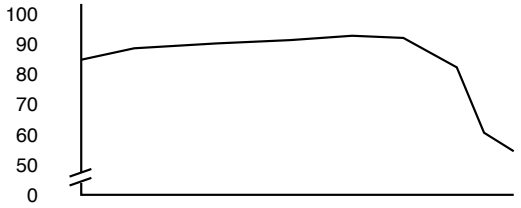

Figure 5. Use a break in the axis to show that the scale is interrupted.

of the scale and the position of the *y*-axis can mislead (Figure 4a).

Where showing the entire vertical scale would require too much white space and compress the details at the top, the solution is to include the zero point and a visual cue that the axis is interrupted, as in Figure 5.

This shows us clearly by way of a visual cue that the curve spans only the top half of the scale.

Tricky or misused terms

The terms listed in this section come up often enough to make them worth commenting on. They're listed in alphabetical order. Some you'll consider not a problem (a regional difference, perhaps); others you'll consider a lost cause. But I believe that the distinctions I explain are worth maintaining.

Address

To address something means to "think about and begin to deal with" it (*Concise Oxford Dictionary*). Where this meaning is too broad for the context, consider a more specific word: assess, resolve, manage, analyse, consider, solve, investigate, control.

Analysis

"Analysis of", not "analysis on".

And & or

When using "and" and "or", be careful to avoid a common trap: using "or" to indicate that both options were used ("and" is more correct in this case) and using "and" to indicate that both options were used, but separately ("or" is more correct in this case):

> We tested two insecticides, A or B, on the borers.

This sentence identifies two insecticides, then confuses matters by offering an alternative—pick one or the other, but not both. It should say:

> We tested two insecticides, A *and* B, on the borers.

Clearly, "A and B" is a plural object, to match "insecticides" (in apposition).

Using "and" for "or" can create a similar problem:

> We sprayed species 1 and 2 with insecticides A and B.

This suggests that both species received both insecticides. If that is not what was meant, then it should say:

> We sprayed species 1 *or* 2 with insecticide A *or* B, respectively.

This now relates each species with its own insecticide. But it would be better written as:

> We sprayed species 1 with insecticide A and species 2 with insecticide B.

Similarly:

> When insects were sprayed with 0.2, 0.5 and 1.0 mg/L chlorfenapyr, mortality was significantly increased.

This really means that the insects were sprayed with all three concentrations at once (if we take a literal interpretation). The author should write:

> When insects were sprayed with 0.2, 0.5 *or* 1.0 mg/L chlorfenapyr, mortality was significantly increased.

That is, the insects were sprayed with one concentration (or another or the other) only—one per insect.

Finally, when you have two parallel lists (e.g. rates then mortalities) related by "respectively" (p 71), make sure that both lists use the same conjunction.

And/or

This is a lazy way to avoid being specific. Usually you can change it to "or". Sometimes it actually means "and". If making a distinction is critical, then rewrite as "A, B or both".

Applied

Many authors seems to think that "used" is not good enough and that they should use "applied", because it sounds more important. In this situation, "applied" is a "bullfrog word"—one that makes noise about its importance. It can be misleading:

> The two-sector model was applied to estimate the P_{fl} value.

Here, "The two-sector model was applied to" sets up the momentary expectation that the next word is a noun, as in "The two-sector model was applied to case B". Here, "applied to" is elliptical (or shorthand) for "applied in order to". The alternative allows no momentary misinterpretation:

> The two-sector model was *used* to estimate the P_{fl} value.

You can find other simple substitutes for bullfrog words in "Appendix 2—Wordy phrases" on p 88.

Based on

"Based on" is a compound participle with an adjectival function that is often used as an adverb. The following examples use it appropriately:

Our laws are based on the Constitution.

The following graph, based on our data, shows this trend.

We constructed a phylogenetic tree based on deduced amino acid sequences …

In all examples it has an adjectival function: in the first, describing the laws; in the second, describing the graph; in the last, describing the phylogenetic tree.

In the following examples, it is used idiomatically, but not grammatically:

Based on our data, we show …

Based on our assumption, the results support our argument.

In both of these examples, it is functioning as a sentence adverb, which is used to modify the sense of a whole sentence. Common examples of sentence adverbs include "Happily, they were rescued"; "Fortunately, it rained in time"; "Hopefully you won't have to go". "Based on" in our examples has the same function, but it can also be taken to imply a nonsense relationship: in the former, it can be read as saying that "we" (the authors) are based on our data; in the latter, that the results are based on the assumption.

To illustrate this point, here is an example in which the same construction is used appropriately:

Based on the twelve-note scale, Arnold Schoenberg's work was highly influential in promoting atonal music.

It says, correctly, that Schoenberg's work was based on the twelve-tone scale. Compare it with the previous examples ("Based on our data, we …"; "Based on our assumption, the results …") and you can see how the same construction in those cases is being used to say something different. However, readers who have come to expect "based on our data" to refer to the results, not to the grammatical placement, might not even recognise this older meaning.

Where the referent is clear, we need not get worked up over the grammatical function of "based on" in a sentence. But there will be instances where readers can take the wrong meaning:

We excluded questionable sites based on the repeat unit.

Readers who understand the function of the compound participle will read this as meaning that the sites are based on the repeat unit. Readers attuned to the sentence adverb function will read the sentence as meaning that the exclusion was based on the repeat unit. This latter meaning is what the authors meant.

Where you feel that readers may take the wrong meaning (by following the grammar, not the idiom), simply change "based on" to "on the basis of" and the grammatical sticking point goes away:

On the basis of our data, we show …
On the basis of our assumption, the results support our argument.

Bimonthly, biweekly

Dictionaries list two meanings for "bimonthly": "occurring every two months" and "occurring twice a month". Readers have no way of distinguishing which meaning an author intends, so always query the author and request unambiguous rewording.

"Biweekly" also is ambiguous. Suggest either "every two weeks" or "twice a week". For publications written in British English, suggest the word "fortnightly" if the meaning is "every two weeks".

cf.

Many people do not know that "cf." means "compare with", from the Latin *confer*. Many authors use it when they mean "see". Always query it unless the author's meaning is clear and correct.

Compared to

Use "compared to" to indicate likeness, "compared with" to indicate contrast. Think of Shakespeare's Sonnet XVIII: "Shall I compare thee to a summer's day?"

Compared with

Never allow things like "The treatment mean was 15% higher compared with the control mean." Correct English requires "than":

The treatment mean was 15% higher *than* the control mean.

Data—count noun or mass noun?

"Data is" or "data are"? Purists (those who learned Latin, like me) insist that "data" is plural—the plural of "datum". When scientists collect data, they collect lots of values. Each value can be considered a datum—a single piece of data. When analysed to reveal meaning, the data provide information. (Thus data are a source of information, not information itself.) But in modern usage, "datum" is used almost exclusively in surveying, in which the datum is the point of reference against which all other points are measured.

On the other hand, most people write "data is", considering data to be a *mass noun*—that is, a single concept considered as a whole, not as a collection of parts. This reflects the fundamental difference between *mass nouns* and *count nouns*. For example, milk is a mass noun—we drink milk, not milks (unless we drink both cow's milk and goat's milk). Distance is a mass noun—however long a distance is, it's one distance, not discrete units to be counted; hence, "3 m is", not "3 m are". In contrast, anything that we can count is a count noun: marbles, sheep, seedlings, cells, patients, stars. (See also "Numerals or words?", p 68.) So should we consider data to be a mass noun or a count noun?

The answer is both. In some cases, the set of data collected by a scientist is a set of discrete values—temperature recordings, rainfall recordings, answers to a questionnaire. These values need to be added, multiplied, transformed, averaged or whatever to reveal useful information. In this case, "data" is plural, particularly when you consider that statistical methods are available for filling in missing data: a single datum (more commonly, a single "data point") can be estimated by linear interpolation, for instance.

In other cases, it is clear that an author is talking about the information that the collection of data represents: "Our data from the troops on the ground *indicates* that resistance is stiff." A single data set takes a singular verb.

So before you routinely change singular data to plural data, or plural data to singular data, depending on the particular bee in your bonnet, ask yourself whether the meaning is discrete values or an uncountable mass.

Due to

In the first *Oxford English Dictionary* (1897) there is no mention of "due to" used prepositionally. In the 1st edition of his *Modern English Usage* (1926), Fowler called those who use "due to" in place of "owing to" illiterate. By the 2nd edition (Gowers, 1965), the tone had softened a little:

> Has *due to*, using the weapon of analogy, won a prescriptive right to be treated as though it had passed, like *owing to*, into a compound preposition?

The 5th edition of the *Concise Oxford Dictionary* (1964) "tersely dismisses it as 'incorrect'." The 6th edition of the *Concise Oxford Dictionary* (1976) doesn't mention it. The 7th edition (1982) merely calls it "disputed". By the 10th edition (2001), the *Concise Oxford Dictionary* includes the following usage note:

> **Due to** in the sense of 'because of' has been condemned as incorrect on the grounds that **due** is an adjective and should not be used in a prepositional phrase.

> However, the prepositional use is now common in all types of literature and is regarded as part of standard English.

The dispute over "due to" goes back to the eighteenth century and Dr Johnson (of dictionary fame), who, according to the Merriam-Webster *Dictionary of English Usage*, felt that it was not appropriate unless a debt was owed ("Thanks are due to …"). "Due to" in its adjectival form appeared at the end of the nineteenth century, and in its prepositional form not long after that. It is now firmly established as a preposition ("Due to wind, the tree fell over"), and no amount of pontificating by fuddy-duddies such as myself will alter that.

If the meaning is clear, there is no point arguing in the face of contemporary usage. However, it is worth preserving a useful distinction in meaning between "due to" and "owing to". Consider the following, in which both are used appropriately:

> In Japan, *P. sieboldii* populations have declined owing to loss or fragmentation of habitats due to human exploitation.

Here, "owing to" is adverbial, describing how the populations have declined, and "due to" is adjectival, describing the loss of habitats. Descriptive grammarians and common usage hold that the two phrases are interchangeable as prepositions. In that case, the following rearrangement should convey the same meaning:

> In Japan, *P. sieboldii* populations have declined due to loss or fragmentation of habitats owing to human exploitation.

But it doesn't. Instead, "owing to", as an adverbial phrase, still attaches itself to the verb, "have declined", conveying the sense that the populations have declined on account of human exploitation. (This is ultimately true, but it leaves out the loss of habitats as the proximate cause.)

"Due to" used prepositionally can lead to misinterpretation. Consider the following:

> Capecitabine is used as a single agent in elderly patients or in patients with comorbidities due to its side-effect profile.

What is due to the side-effect profile: the use in elderly patients or the comorbidities? When we think about it, the second interpretation is illogical. But why put readers through the same exercise when we can make it clear for them:

> Capecitabine is used as a single agent in elderly patients or in patients with comorbidities *on account of* its side-effect profile

or even better:

> *Because of* its side-effect profile, capecitabine is used as a single agent in elderly patients or in patients with comorbidities.

For

"For" is often misused, in a lazy sort of shortcut. Beware situations in which the author unintentionally attributes a favour or a gift to something through the incorrect use of "for" in place of "in", "of" or another preposition.

> Smith and Brown (1985) developed a pressure probe method for estimating P_{f1} and P_{f2} for *Chara collarina* cells.

The first "for" ("for estimating") is correct. The second is not. Nobody estimated P_{f1} and P_{f2} *for Chara collarina* cells—the cells don't care. The correct preposition here is "of":

> Smith and Brown (1985) developed a pressure probe method for estimating P_{f1} and P_{f2} *of Chara collarina* cells.

> For India, the annual cost of providing a centralized connection of piped water to households is expected to decline more by improving the efficiency of water supply management than by reducing unaccounted for water.

This was not done *for* India. Use "in":

> *In* India, the annual cost of providing a centralized connection of piped water to households is expected to decline more …

> The results indicated considerable variation for self-compatibility.

Use "in":

> The results indicated considerable variation *in* self-compatibility.

Again in this next example, "for" suggest some sort of favour (where "for" = "on behalf of"):

> We first calculated the absolute chromosome volume for each chromosome.

Substitute "of":

> We first calculated the absolute chromosome volume *of* each chromosome.

The most common alternative prepositions are "in", "of", "on", "to".

g and rpm

Centrifugation must be described in terms of gravities (*g* or ×*g*), not rpm (revolutions per minute). The reason is that *g* is a force (9.8 m/s^2 × mass), and rpm tells you nothing about what force is acting on the particles in the suspension. The

formula for centrifugal[1] force (the force acting on a rotating mass) is $f_c = mv^2/r$, where m = mass, v = velocity and r = radius (distance from centre of spin to centre of mass). In contrast, rpm doesn't tell you m, and you can't work out v, because you don't know r (to work out the circumference of the path traced by the sample, $2\pi r$, since different models of centrifuge have different radii), only the period of rotation. Without this information, you cannot know the force acting on the sample. This is critical, because a centrifuge with radius 100 mm acting on mass m and spinning at 2000 rpm applies the same force to the sample as another centrifuge with radius 25 mm acting on mass m and spinning at 4000 rpm. Using rpm hides potentially important information.

Note that *g* is always written in italic to distinguish it from grams. The "×" is optional, but it helps reinforce that the *g* is not grams.

In order

Most style guides will tell you to delete "in order" because it's padding. This book is no exception—where it's padding. But there are situations where "in order" is useful. How do you interpret the following sentence on first reading?

> In general, long shoots need more resources to be produced than short shoots do.

This seems to be saying that the long shoots need the tree to produce more resources. Consider the following substitution:

> In general, the company needs more resources to be produced …[2]

It's clear here that the company has specified this requirement. By analogy, in the example above, it appears that the long shoots have stated their preference too. Now let's insert "in order" and see how the meaning becomes unambiguous:

> In general, long shoots need more resources *in order* to be produced than short shoots do.

---

1. Strictly speaking, it's centripetal force. Centripetal force is the centre-seeking force that must be applied to balance centrifugal force (the "throwing out" force). Centripetal force exerted by the test tube in the centrifuge is what keeps the liquid inside the centrifuge instead of spattering on the walls. Most physicists disparage the use of "centrifugal" force, because it is a ghost force that results from inertia, and exists only because in a rotating frame of reference, you can measure the strain in whatever object (e.g. a yo-yo's string) stops the object from flying away at a tangent.

2. In earlier English, as in other modern languages, we would have said "the company needs *for* more resources to be produced". But we would not have used it in the original example, where "in order" indicates the correct meaning. This useful distinction is effectively lost.

That is, in order for long shoots to be produced, the long shoots need more resources. Having identified the intended meaning, we can make it even clearer:

> In general, *the production of* long shoots needs more resources than *the production of* short shoots.

This now makes it clear that the production, not the shoots, needs the resources. (This was, indeed, the intended meaning.)

In most cases you can delete "in order". But be sure that deleting it doesn't change or muddy the meaning, because sometimes it can clarify.

Media

One medium, two media. Growth media "are", not "is". Don't allow "medias". (Even when the meaning is newspapers, television and radio, the plural is still "media".)

Methodology

Don't confuse methodology with method. Methodology is the set of individual methods. Most "methodologies" are nothing more than methods.

Non and other prefixes

In British English, words made negative with a prefixed "non" tend to be hyphenated. In US English, they tend to be closed up. Whether they are hyphenated or unhyphenated, the meaning is clear. Except sometimes. Instead of automatically following the rule to close up, make sure first that the result is not odd or misleading. "Nonnative", "nonnacreous" and "nonpoint-source" fall into this category. "Nonnative" suggests something that "nonnates". "Nonnacreous" suggests something to do with Italian grandmothers, to be hyphenated "nonna-creous". In such instances, insert the hyphen for clarity: "non-native", "non-nacreous". Further, a "nonpoint-source" is not a source from a nonpoint. Instead, it is a source that is not a point source, and for clarity should be written "non-point-source". Blind adherence to a rule can sometimes reduce readability.

Other prefixes can pose problems too: "posteruption" suggests "poster-uption", instead of "post-eruption"; "preenrolment" suggests "preen-rolment" instead of "pre-enrolment"; postthaw" contains a stutter; "subboreal" could be something to do with a "subbor". The conclusion we can draw from these examples is akin to one of the rules of hyphenation—don't make the word look as though it contains an entirely

different word (such as poster or preen) when judicious use of the hyphen can improve readability. Remember: hyphens are the reader's pal!

Numerals or words?

Scientific Style and Format (Council of Science Editors 2006) recommends writing all numbers as digits, not words:

> Use numerals rather than words to express whole and decimal numbers in scientific text …

After some examples, it then lists the exceptions:

- at the start of sentences
- where two numeric expressions are adjacent
- one and zero in general usage
- in idiomatic usage.

Where brevity and conciseness are important, numerals are preferable. In science, in particular, we expect numeric values. Further, numerals are quicker and easier to comprehend than words. Just compare "thirteen, twenty-seven, one hundred and nine, two thousand three hundred and ninety-nine" with "13, 27, 109, 2399". The numerals win. (And for people from a different language background, numerals are much faster to comprehend than words whose meanings have to be translated first.)

This style also avoids uncritical adherence to the "rule" that you must spell out words up to nine (or ten) and use numerals above that limit, which can lead to uglinesses such as "We counted one, three, 10, 67, and five occurrences, respectively." Consistency aids comprehension. This sentence could be better written either with all numerals or with all words. Our brains process numerals and words differently, and having to switch repeatedly between linguistic and symbolic representations of the same concept impedes comprehension.

To summarise, if you can count it or measure it, use numerals.

But "**one**" can be tricky. Should we write

> When a letter of smaller value follows one of equal or higher value

or

> When a letter of smaller value follows I of equal or higher value

In other words, when should you use "one" in preference to "1"? A useful test is whether you can put "of them" after "one" to get "one of them" and it still makes sense in context. In that case, write "one". You would use "one" in the following

examples:

We substituted the faulty instrument for one of equal quality.

It is thought to be one of the most effective methods.

This was one of the reasons for …

In all examples, the construction is "one of". "One of" here is used in the sense of "an example of" rather than enumerating something. This is a pronominal use (pronoun), not adjectival (describing how many).

Note, however, that we can put "2" in here and the sentences still make sense:

We substituted the faulty instruments for 2 of equal quality.

They are thought to be 2 of the most effective methods.

These were 2 of the reasons for …

Contrarily, these examples illustrate things that *can* be counted, so we *can* use numerals. This implies then that we can write "We substituted the faulty instrument for 1 of equal quality." However, it looks funny. On its own that's enough reason not to do it. But in this case we are not counting the instrument. Instead, "one" here is a substitute for "an", in the sense of "an instrument". This is a distinction that we can make in English that many other languages can't make. For instance, French doesn't distinguish between "a book" (*un livre*) and "one book" (*un livre*). English can and does distinguish, and the difference can matter. This then is the critical distinction between "We substituted the faulty instrument for one [*an* instrument] of equal quality" and "We substituted the faulty instruments for 2 [instruments] of equal quality". The first uses "one" as a pronoun; the second is counting (adjectival).

Observed

The *Concise Oxford Dictionary* defines "observe" as "notice, perceive, watch attentively, detect in the course of scientific study". Although this latter definition would seem to cover all uses of "observed" in scientific writing, the former meanings denote paying attention to something. Observation in this sense is an active process. But when authors in fact recorded, measured, noted, calculated or found something, this sense of paying attention is absent.

Observing the mating rituals of antelope is an accurate use of the word. Observing a significant difference isn't. A significant difference is found or calculated. Temperatures are not observed, they are measured or recorded. Inhibition of cell proliferation is not observed by other authors, it is reported.

Often "observed" is correct, but sometimes a more accurate word is needed.

Keep in mind, though, the need to avoid what Fowler called "elegant variation", the substitution of synonyms to avoid repetition. This can draw attention to the substitution and can suggest a different meaning where no difference is intended.

Parameter

"Parameter" and "variable" are often used interchangeably, but the distinction is worth preserving. In statistics, parameters are typically summary statistics (such as means). Elsewhere, they are equivalent to "independent" variables; that is, they may "vary" (take on different values), but the variation is typically controlled by the experimenter. The parameter determines the values of other variables. It is not any old variable.

The temperature of a system (a borehole, a glasshouse, a body) is a parameter because it determines important characteristics of that system; it describes (or summarises) that system. But the temperature of an individual patient in an epidemiological study is not a parameter, because it does not characterise the disease under study. The difference can be subtle.

In a mathematical example, in $ax^2 + bx + c = 0$, a, b and c are parameters.

A common error in scientific writing is to call all variable quantities parameters. When you come across this term, ask yourself whether the variable actually characterises the system or determines other variables. If it does, it is a parameter. If not, it is a variable, or a descriptor.

Phenomena

One phenomenon, two phenomena. Don't allow "phenomena is" or "phenomenas".

Post and pre as adverbs

In English, "post" is a prefix, not an adverb, and is not a whole word, but a fragment. Don't write or allow "The data were downloaded post collection" or "The patients were interviewed post surgery." The role of "post" is to modify words, as in "post-harvest biomass" (adjective), "post-date a cheque" (verb), "postdoctoral student" (adjective). We already have the common word "after". Writers who use "post" as an adverb have succumbed to the belief that it imparts an air of authority or learnedness to their writing, when it simply supplants a more common word. Everyone knows "after"; many don't know "post". Don't let it pass.

The same applies to "pre".

Respectively

"Respectively" means "separately or individually and in the order already mentioned" (*Concise Oxford Dictionary*). Fowler (*Modern English Usage*, 2nd ed.) opined: "Delight in these words [respective, respectively] is a widespread but depraved taste …; of ten sentences in which they occur, nine would be improved by their removal." In his idiosyncratic way, Fowler was saying that "respectively" was overused. It still is.

Scarcely a scientific paper crosses my desk that does not use "respectively". In many cases, as Fowler observed, it can be removed, and meaning can be improved.

Consider this type of sentence:

> The yields were 25, 54, 78, 104, 134, 178, and 202 kg/ha in the 2.5, 5.0, 10.0, 20.0, 30.0, 40.0, and 50.0 g/m^2 treatments, respectively.

This construction requires the reader to jump back and forth seven times[1] to understand which treatment gave which result. All these values look pretty much the same—they're all numbers—so it is easy to jump to the wrong number and mentally associate the wrong result with a treatment. So the reader must read again, perhaps a few times, to understand the meaning of the sentence. This is unfair.[2]

Instead, the sentence could be written like this:

> The yields were 25 kg/ha at 2.5 g/m^2, 54 kg/ha at 5.0 g/m^2, 78 kg/ha at 10.0 g/m^2, 104 kg/ha at 20.0 g/m^2, 134 kg/ha at 30.0 g/m^2, 178 kg/ha at 40.0 g/m^2, and 202 kg/ha at 50.0 g/m^2.

Obviously this is longer, but the meaning is now clear; each treatment is unambiguously associated with its result. Conserving space in scientific texts is important, but it can be taken to extremes. Clarity of meaning takes precedence over compactness.

If space is at a premium, the sentence could be shortened thus:

> The yields were 25 kg/ha (at 2.5 g/m^2), 54 (5.0), 78 (10.0), 104 (20.0), 134 (30.0), 178 (40.0), and 202 (50.0).

As in the original sentence, the units are presented only once, but this time up front, thus setting the pattern for the rest of the sentence. This shows the advantage

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1. Note that this problem does not arise with short lists of a few items, which can be easily kept in memory.

2. Note, though, that where trends are apparent, this can be more important than the actual values, and so "respectively" serves a useful purpose here.

of placing the units or identifiers up front in long lists of items: the reader doesn't have to wade through several lines of text, juggling several things mentally, until the resolution finally comes.

An alternative solution, which can make the information crystal clear, is to reorganise it into a table. That way, readers get even more information, because they can search the table for trends rather than holding all those numbers in memory.

Often, however, "respectively" can serve a useful purpose, so consider your options before removing it. For example:

> Smith (2000) and Jones (1999) studied the transcription of *Pqr1* in response to cold stress in *Arabidopsis* and rice, respectively.

The simple structure of the relationship here—only two authors with only one plant each—allows the association to be made without mental gymnastics. The alternatives are unhelpful, because the original was clear:

> Smith (2000) studied the transcription of *Pqr1* in response to cold stress in *Arabidopsis*, and Jones (1999) studied the same thing in rice.

> Smith (2000) studied the transcription of *Pqr1* in response to cold stress in *Arabidopsis*, and Jones (1999) studied it in rice.

> Smith (2000) studied the transcription of *Pqr1* in response to cold stress in *Arabidopsis*, and Jones (1999) in rice.

The first is no improvement on the original. In the second, "it" could stand for "the transcription of *Pqr1*" in an unspecified condition (such as salt stress). In the third, the grammar of the sentence says that Smith studied Jones in rice. Given the possibility of ambiguity or simply of saying something silly, "respectively" has it uses.

Be sure when deciding to keep "respectively" that all items match. Occasionally I find a sentence like:

> Samples were collected from stations 1, 2, 3, and 4 in June, July, and August, respectively.

This highlights that something is missing. A query to the author is in order.

In literary analysis, "respectively" is referred to as an "advance organiser", which tells the reader: "match this new list with the list of things I just presented, one at a time, in exactly the same sequence". Such cueing can improve readability, provided "respectively" is presented early.

When you have two parallel lists (e.g. rates then mortalities) related by "respectively", make sure that both lists use the same conjunction (both use "and" or both use "or").

There are occasions when "respectively" serves a useful purpose, but finds itself in the wrong place:

> $\boldsymbol{H}_g$ and $\boldsymbol{E}_g$ are modelled as being proportional to differences in temperature and humidity between ground and air within the vegetation, respectively.

On first reading, it is not immediately clear what should be associated with what. But shift "respectively" to the right place, and the association becomes clear:

> $\boldsymbol{H}_g$ and $\boldsymbol{E}_g$ are modelled as being proportional to differences in temperature and humidity, *respectively*, between ground and air within the vegetation.

In summary, "respectively" has its uses, but some sentences can often be improved by removing it and rearranging items. And in case you are not convinced, consider the following example that was received by the *Journal of Natural Resources and Life Sciences Education* (1993; 22(2): 198–199):

> Planting was done on 20, 25, 28, and 3 of May, May, May, and June in 1985, 1986, 1987, and 1988, respectively.

Why did the author think this was better than:

> Planting was done on 20 May 1985, 25 May 1986, 28 May 1987, and 3 June 1988.

I'll leave you with the following example to decipher:

> The $^{13}CO_2$ was supplied to six and three plants grown under AMB and FACE conditions on 65 DAT (Jul 25) and 80 DAT (Aug 9), and on 96 DAT (Aug 25) and 107 DAT (Sep 5), respectively.

This could be read as meaning one of the following:

> The $^{13}CO_2$ was supplied on 65 DAT (Jul 25) to six plants grown under AMB and on 80 DAT (Aug 9) to three plants grown under FACE conditions, and to something else on 96 DAT (Aug 25) and 107 DAT (Sep 5).

> The $^{13}CO_2$ was supplied to six plants grown under AMB on 65 DAT (Jul 25) and 80 DAT (Aug 9), and to three plants grown under FACE conditions on 96 DAT (Aug 25) and 107 DAT (Sep 5).

> The $^{13}CO_2$ was supplied to six plants grown under AMB on 65 DAT (Jul 25) and 96 DAT (Aug 25), and to three plants grown under FACE conditions on 80 DAT (Aug 9) and 107 DAT (Sep 5).

Sacrificed

"Sacrificed" for "killed" is common in scientific reports involving animal experiments. This use can be justified from the point of view that to the researchers, the death of a laboratory animal is a sacrifice of resources in pursuit of a higher good.

But it does diminish the strength of the word for people who lay down their lives or go without food for their higher cause.

In disciplines where "sacrificed" is not the standard term, suggest "killed". "Sacrificed" comes too close to being a euphemism.

If you really want, you can instead use "euthanase", "euthanise" or "euthanatise". The literal meaning of euthanasia is "good death". This is an accurate description of how laboratory animals are killed, provided, of course, that animal welfare rules are followed.

Sex and gender

These two words are not interchangeable. Sex is biological, gender is social or grammatical. The difference can be significant.

A study that takes into account the participants' sex allows for differences in results that are caused by differences in gene expression under the control of sex hormones, ultimately driven by the X or Y chromosome. Sex differences are many and important.

In contrast, gender is a social construct. We identify as male or female, sometimes in contradiction of our sex chromosomes. A woman who was born male but identified as female and had a sex-change ("gender reassignment") operation is socially female, and therefore of the female gender, but still has male structures in the brain and pelvis, and a Y chromosome, and is therefore still biologically male. And some people are born with an XY genotype, and are thus genetically male, but develop into females because of a mutation or deletion of the *SRY* gene, which is the male-determining gene. They are thus of the female gender, but of the male sex.

Finally, gender is a grammatical feature. English has four genders: masculine, feminine, neuter and common. German has three (masculine, feminine, neuter). French has two (masculine, feminine).

Studies on/of

Prefer "studies of".

To be

Among other things, the verb "to be" is a copulative verb, linking words related in sense. In effect, it equates one thing with another. For example, "The leaves were yellow" equates "leaves" with "yellow". We could write this as "leaves = yellow" and the meaning would be preserved. (And when I wrote "the verb 'to be' is a copulative verb", I was using it there as a copulative verb: "'to be' = copulative verb".)

However, many writers use "to be" to link things that are not equatable. For example, "The trial was in 2005" says "trial = in 2005". This is a poor use of "to be", because a trial is not the same as "in 2005". In these situations, "to be" is a weak verb; it weakens the meaning of the sentence. Fortunately, the solution is easy: substitute another verb, one that is more appropriate to the sense; a strong verb. If we change "was" to "was held" (note that we are not simply inserting "held", we are exchanging the copulative "was" for the compound verb "was held"), we get "The trial was held in 2005". We don't have to ask "The trial was what in 2005?", or interpret the sentence as meaning "The trial existed in 2005"; the sentence is stronger, and the meaning is clear.

But the sentence remains in the passive voice (see "Active versus passive voice" under "Improving expression"). We can improve it still further by rewriting it in the active voice: "We held/ran/conducted the trial in 2005."

Here are some more examples:

> Ears that <u>were</u> before pollination …

This peculiar phrasing says "ears = before pollination", which doesn't stand up to scrutiny. We can change it to:

> Ears that *had not been pollinated* …

> The liverwort <u>is</u> frequent in coastal areas.

Although this is a common enough usage, we can nevertheless strengthen the message:

> The liverwort *grows commonly* in coastal areas.

> Milk <u>is</u> from cows.

This statement tells us what milk *is* ("from cows"). What it should tell us is:

Milk *comes* from cows.

The test subjects were unhappy.

Again, this is common and unexceptionable,[1] but we can be more specific:

The test subjects *felt* unhappy.

Measurement plots were in the same fields.

"Were" in the sense of "existed" (if you know Italian, think of the verb *stare*) is correct. But we can liven this sentence thus:

Measurement plots *were established* in the same fields.

This tells us what happened, not just what existed. But it's written in the passive. In the active it would become:

We established measurement plots in the same fields.

But don't throw the baby out with the bathwater. "To be" has many valid roles if we put the weak uses aside. One of the most important is as an auxiliary: "was measured", "is measured", "will be measured" and so on convey important information about time.

Ton

A ton is an irrational unit of mass defined as either 2240 pounds (another irrational unit) for a "long ton" or 2000 pounds for a "short ton". The long ton is equivalent to 1016 kg, or very close to a tonne (1000 kg). Always use the metric *tonne* (t) (rhymes with John), not the Imperial *ton* (rhymes with sun), unless the publisher specifically directs otherwise. As the long ton conversion is close to 1:1, you can get away with using the same values if the meaning is approximate, but not if the degree of precision is critical. Given the possible confusion between the two definitions of a ton, always insist on the tonne (not "metric ton", or "metric tonne", just "tonne").

Using

"Using" is not a preposition, but it is often used that way. This is the way language evolves, but this particular usage causes ambiguities. Consider the following titles,

1. Note, however, that the original ("were unhappy") can lead us into existential waters. How do we know that the subjects *were* unhappy? We can't get inside someone else's head, so we can never know for sure how they feel. We can only report what we see. So, "The test subjects seemed unhappy" might be better.

the sort of which you've seen many times:

> Abomasal cannulation in the milk-fed calf using a 7 mm polyurethane tube
>
> Characterization of water quality factors during intensive raceway production of juvenile *Litopenaeus vannamei* using limited discharge and biosecure management tools
>
> Discrimination of *Francisella tularensis* subspecies using surface enhanced laser desorption ionization mass spectrometry and multivariate data analysis
>
> Feature selection algorithms using Chilean wine chromatograms as examples

We know what they mean. The first *means* "cannulation by means of a polyurethane tube". The second *means* "characterisation by means of limited discharge". The third *means* "discrimination by means of mass spectrometry". The fourth *means* "algorithms explained by means of wine chromatograms". But this is not what they *say*.

Taken literally (to highlight the grammatically implied meaning), the first refers to a calf using a polyurethane tube. The second refers to juvenile prawns using limited discharge. The third refers to *Francisella tularensis* subspecies using lasers. And the fourth says that the algorithms use chromatograms. But why should we worry about the literal meaning if we know what the authors mean? Because there remains the opportunity for misinterpretation (by readers from a non-English-speaking background, for example), or the literal meaning can stand out, masking the intended meaning by being amusing. Consider the following example:

> This was to be accomplished by gathering data from the babies using the standard monitoring devices.

Doesn't this refer to babies using monitoring devices? To understand my point, consider the following examples, which are grammatically and structurally identical to each other:

> New Caledonian crows were seen using tools.
> New Caledonian crows were seen using binoculars.

The first sentence is remarkable for what it implies about tool use—New Caledonian crows provide the first recorded example of birds that fashion tools for use in gathering food. The second sentence is identical in grammar and structure to the first, so it should be identical in meaning—that is, not only can New Caledonian crows create tools to use to collect food, they can also use binoculars. But the second sentence is, though made up, typical of sentences in which "using" is misused, but we

are expected to ignore the literal meaning and interpret what the author *meant* to say.

Another typical usage is:

The cells were counted using a flow cytometer.

Let's do some substituting in this sentence:

The runners were timed using a stopwatch.

The runners were timed running a kilometre.

All three sentences are identical in structure and grammar—noun, compound verb, present participle, noun. So all three should convey their meaning the same way. As the third sentence shows, the runners ran a kilometre. Therefore, according to the second sentence, the runners used a stopwatch. So the cells used a flow cytometer.

Obviously, "using" has taken on its own special meaning, but as I've shown above, it can be misread. So what's the solution? The simplest solution is to insert "by":

New Caledonian crows were seen *by* using binoculars.

… gathering data from the babies *by* using the standard monitoring devices.

The cells were counted *by* using a flow cytometer.

This simple insertion changes the form from a participle into a preposition + participle, giving us a prepositional phrase: *by* + a means for achieving something. How were the cells counted? *By* using a flow cytometer. This is identical to saying "by the use of a flow cytometer".

Other alterations are also possible:

through the use of by means of with by

and others. So instead of the ambiguous "using", we can say:

The runners were timed *with* a stopwatch.

… gathering data from the babies *through the use of* the standard monitoring devices.

… discrimination *by means of* mass spectrometry.

It is worth explaining a bit more by analogy. Other participles are also used in many places:

We evaluated the effects of 15 organic solvents *by determining* the luminescence volume induced by each solvent.

We determined tree heights *by measuring* the diameter at breast height and using an isometric relationship.

> The seed weights were determined *by weighing* on an electronic balance.
> (Even better: We *weighed* the seeds on an electronic balance.)

We would not write:

> We evaluated the effects of 15 organic solvents *determining* the luminescence volume induced by each solvent.

> We determined tree heights *measuring* the diameter at breast height and using an isometric relationship.

> The seed weights were determined *weighing* on an electronic balance.

Nevertheless, "using" is correct in many places. For example:

> Effects of organic solvents in luminescent *umu* tests using *S. typhimurium* TL210

In this case the testing uses *S. typhimurium*.

As a final comment, the fourth example given at the start of this section—"Feature selection algorithms using Chilean wine chromatograms as examples"—cannot be remedied by inserting (note: "by inserting", not "inserting") "by": no action is described. What "uses" the chromatograms is the study itself, not anything in the title. Hence my insertion of "explained": "algorithms *explained by means of* wine chromatograms".

Watershed

Despite the latitude of dictionaries, a useful distinction can be made between a watershed and a catchment. A watershed *sheds* water. A mountain range is a watershed. (And in figurative use, a watershed is a dividing moment.) A catchment *catches* the shed water, which then flows into a river.

While

Like "with", discussed in the next section, "while" is commonly used as a conjunction. It is unremarkable in many cases, but nevertheless conveys a sense of relatedness in time. Sometimes this is obviously illogical and needs to be changed. At other times it's fine.

Consider each occurrence carefully. Some you can leave:

> While yield was increased in the +P plots, it was reduced in the –P plots at harvest.

This is perfectly understandable as indicating that two results are being contrasted. But others you need to revise:

> Leaf area was recorded weekly while the dry weights were determined at the end of the experiment.

Because "while" implies simultaneity, the sentence implies that leaf area was recorded *at the same time as* the dry weights were determined, even though these events happened weeks apart. Use "and":

> Leaf area was recorded weekly, *and* the dry weights were determined at the end of the experiment.

This very simple change removes the problem. Also note the inserted comma, which separates the two distinct statements, adding a further cue that these events were not simultaneous.

> While police are at the Institute to learn how to identify marijuana, Dr John Kelp is building a catalogue of seaweeds.

And when they leave, Dr Kelp will stop work on his catalogue? Again, "while" implies simultaneity. This should have been two sentences. Even two paragraphs. The ideas are not obviously related.

> Police are at the Institute to learn how to identify marijuana. [In separate work,] Dr John Kelp is building a catalogue of seaweeds.

Remember that "while" has been in common use in English as a conjunction for over 250 years, so it is not always necessary (or even desirable) to change it, unless it suggests a meaning of simultaneity that is obviously not present (or possible). The key point is to make the meaning clear while [!] avoiding saying something funny.

With

A common habit among all writers is to use "with" to join two ideas. (See the discussion of "while" for a similar situation.) Often it is perfectly unexceptionable, but in other cases it is lazy and can give a misleading impression of relatedness between unrelated events or things. For example, "His Notice of Motion was defeated with Council instead resolving …" The sentence momentarily suggests that the notice was "defeated with Council". The reader has to reread the sentence and mentally insert the correct punctuation. The best solution is to use punctuation to separate ideas:

> His Notice of Motion was defeated. Council instead resolved …

Here are some more examples.

Growers discuss palmette training system with mobile platform in background.

What the mobile platform said is not recorded. The two statements are not related. Break the sentence into two:

Growers discuss palmette training system. Note mobile platform in background.

Two new Cannabis Section members were recruited during the month with Hubert Goodnose and Randolph Bean to commence at Outer Wetdirt on the 5th March.

So who were the two new members recruited with Hubert and Randolph? Break the sentence up. But because the first sentence here leads into the second, use a colon:

Two new Cannabis Section members were recruited during the month: Hubert Goodnose and Randolph Bean will start at Outer Wetdirt on 5 March.

The meeting was well attended with 100 people present.

Clear enough. But consider a logical alternative: "The meeting was well attended with 50 people absent." This implies that the absent people attended. There are two ideas here. They don't warrant separate sentences, because they are related. A colon will do nicely:

The meeting was well attended: 100 people came.

The logical alternative can be remedied easily, too, with the small addition of a comma and a contrasting conjunction, which warn the reader of a change in direction:

The meeting was well attended*, but with* 50 people absent.

The Potter spray tower was operated at 69 kPa spray pressure with the whiteflies treated on the leaves.

The spray tower was operated with the whiteflies? This is a poor use of "with" as a conjunction. There's no relationship between these two ideas, so they should not be joined.

The Potter spray tower was operated at 69 kPa spray pressure. The whiteflies were treated on the leaves.

In U-E, *Q. sativa* showed significantly larger relative radial growth than *C. japonica* and *Q. myrsinaefolia*, with an intermediate value for *Pinus densiflora*.

This suggests that *Q. sativa* had an intermediate value for *Pinus densiflora*.

In U-E, *Q. sativa* showed significantly larger relative radial growth than *C. japonica* and *Q. myrsinaefolia*, and *Pinus densiflora had* an intermediate value.

A chirally pure dinuclear Ru–Pt species has been successfully synthesised, with

> further biological studies required.

In this example, "with" is misleading not only for suggesting a relationship between the Ru–Pt species and further biological studies, but also for implying an additive relationship instead of an exception.

> A chirally pure dinuclear Ru–Pt species has been successfully synthesised, *but* further biological studies are required.

> Anthesis itself, recorded when the petal segments separated from each other, mainly occurred during the morning with a second, smaller peak of flower opening in the afternoon.

This suggests that morning and afternoon anthesis occurred simultaneously.

> Anthesis itself, recorded when the petal segments separated from each other, occurred mainly during the morning, *followed by* a second, smaller peak of anthesis in the afternoon.

This later sentence from the same paragraph suggests a relationship of "anthesis with maximum fertility":

> Artificial pollinations showed that the period of female receptivity lasted from 5 days before anthesis to 3 days after anthesis with maximum fertility, as judged by seed set, occurring on the day of anthesis.

In fact, these are two separate results:

> Artificial pollinations showed that the period of female receptivity lasted from 5 days before anthesis to 3 days after anthesis, *and that* maximum fertility, as judged by seed set, occurred on the day of anthesis.

Errors in classical languages

Latin and Greek have formed the basis of science and medicine since science was alchemy and medicine was leechcraft (and Arabic provided many of our mathematical terms). These days, few people study them, which is why we as editors must look after their interests. The rules of word formation from Latin and Greek operate not only in English, but in many other languages besides, and many people still expect the rules of usage to apply (notably those who *have* studied the Classics, and authors from a non-English-speaking background who are familiar with the rules in their own language). Not following the rules can make authors look inept. Flexible word coinage is probably the third most notable feature of English (after the sheer

size of the corpus and the bizarre spellings), and authors are forever coining new words. But we need to help our authors avoid looking unlearned to their readers.

Erroneous Latin

Not all words that look Latin are Latin, and so don't follow the rules that govern Latin use; for example, conundrum, rumpus, caucus and ruckus. Other words are of Latin origin but never take a Latin plural; for example ignoramus (a verb in Latin), omnibus (dative plural) and rebus (ablative plural). These always take the English plural. Still other words of Latin origin use the Latin plural, but it's not what you might think; for example stoma (stomata), stigma (stigmata), genus (genera), corpus (corpora), apparatus (apparatus), nexus (nexus), impetus (impetus) and status (status). As you can see from the variation in these examples, it's sometimes easier to simply memorise the seeming exceptions than it is to seek consistent and obvious underlying rules.

Many words of Latin origin are firmly English words and follow English rules. The following words are mistakenly treated as though they follow Latin rules, not English rules.

Calli

"Calli" is the Latin plural of the Latin word "callum". "Calluses" is the English plural of the English word "callus". Change this. (Callus is an *English* word. We don't go to the podiatrist to complain of calli on our feet.)

In silico

The term "*in silico*" was coined by author Joshua Quittner in his article "Artificial Life Gets Real" in *Newsday*, 21 July 1992:

> Some a[rtificial]-life researchers claim they are creating life forms on computers, *in silico* creatures as truly alive as the bacteria studied *in vitro*.

Quittner evidently though it meant "in silicon", as in "silicon chip". It doesn't. Perhaps he was just trying to be witty or helpful, and no one realised. "*In vitro*" and "*in vivo*" literally mean "in glass" and "in life", but "*in silico*" fails in its analogy. Literally it means "in rock". If we can stretch the analogy of rock to silicon to silicon chip, then yes, it's recognizable, and it passes the test of having been adopted by a great many computational biologists. But it is ambiguous as well as bad Latin. It can be used to mean "on a silicon chip" or "by computer". The former meaning is pertinent to "lab on a chip" studies, in which entire suites of laboratory tests can be

run in nanolitre amounts in channels etched on silicon chips. The latter meaning can be clarified by substitution with "by computer". This meaning is pertinent to computer simulation and modelling studies. These two possible interpretations illustrate why it is preferable to use precise, clear and common terms.

Virii

I see this often on the Internet. The plural of the English word virus is viruses. The plural of the Latin word *virus* (for slime), *viri*, was virtually never used by anyone in ancient Rome, because it's the same as the word for "men" (and who wanted to talk about slimes?).

Octopi

The word "octopus" comes from the Greek: *okto* (8) + *pous* (foot). It is Latinised, but it is not a Latin word. The plural is "octopuses", "octopodes" (four syllables) or "octopods".

Platypi

The same argument as for octopus goes for platypus, which comes from the Greek *platus* (flat) + *pous* (foot). The plural is "platypuses" or "platypodes" (four syllables).

Hellenolatinisms

"Television? The word is half Greek and half Latin. No good can come of it." So Charles Prestwich Scott (1846–1932), a British journalist, publisher and politician, is supposed to have remarked.

What prompted him to say this? Scott, like a good many others of his time, would have been schooled in the Classics. It has been a "rule" for centuries in English that when a new word is coined from Classical roots, like goes with like.[1] Hence we have *rhinoceros* (Greek + Greek), *transcribe* (Latin + Latin), *stethoscope* (Greek + Greek), *multiply* (Latin + Latin). Thousands of words in English take this form. Yet despite his admonition, the word was instantly and broadly adopted. Why? Because it looks like other linguistic hybrids formed by means of mixed marriages between languages. There are many other well-established exceptions, such as *bureaucracy* (French + Greek), *multimeter* (Latin + Greek) and *polysaccharide*

1. "English does not borrow words from other languages, it follows them down dark alleys, mugs them, and rifles through their pockets for loose words."—attributed to various

(Greek + Latin). This is how English works.[1]

Every now and then an author will find the need to coin a new word. For example, *multimer* (Latin + Greek) crops up every now and then. In this case a perfectly good word already exists with the intended meaning: *polymer* (Greek + Greek). There's no need to coin a neologism when a suitable word already exists. That's the hallmark of *bad* jargon.

But what if an author comes up with *ailurocide* (one I made up) to mean "cat killer"? Most other -cide words come from Latin, prepending the Latin word for the deceased onto "-cide", which derives from the Latin *caedere*, "to kill"; for instance, *suicide*, *matricide*, *insecticide*. Following the well-established pattern, the word should be *felicide*. Following the pattern can be an important clue to readers who have not encountered a word before. If it obviously follows a pattern, the meaning can be easier to discern.

Some rules, such as to not split an infinitive, are based on a misunderstanding of how English grammar differs from Latin grammar. But the "like-with-like" rule and the "follow the established pattern" rule are useful ones, because they establish patterns that can help readers determine the meaning of new words.

1. The well-tempered neologism follows well-established rules of word formation, even if the origin of those rules is not clear, and has clear parallels with other existing and well-accepted words; for example, *television* was probably accepted so readily because *telescope* was already part of the language. Whether the word is formed according to strict rules is less important than whether it *appears* to follow those rules (i.e., whether similar words exist). This allows readers to accept those words as valid (and not to see them as sticking out like sore thumbs) and to help them understand their meaning.

Appendix 1—Editing techniques

For the most comprehensive guide to editing on-screen available, you can't go past *Effective Onscreen Editing: New Tools for an Old Profession*, by Geoff Hart (http://www.geoff-hart.com/).

This section elaborates on some of the points I make in the main text.

Break long sentences up

Try to follow the rule of one statement per sentence, one idea per paragraph. This aids reading by "chunking" pieces of information (that is, breaking it into chunks). Readers will then not be misled by a confusion of overlapping or poorly differentiated ideas. Bear in mind, though, that many complex concepts can be expressed only in complex sentences, and that scientists have a greater than average reading age, so although clear expression is always important, it's not as critical to simplify science for scientists as it is for non-scientists.

To the extent possible, then, break sentences up into their individual ideas, but you must balance this with not creating a machine-gun style of prose.

Cross-checking references by macro

I created a basic MS Word macro that makes cross-checking references and citations easy. This allows you to avoid many subtle errors that crop up in referencing. This is an important step in the editing process, because many publishers do not check reference lists; they rely on the authors to get them right. Consequently, many inaccurate reference lists go to print.

The code is reproduced below. To use it, you open your working file and then create a second document (don't have more than two documents open or it won't work). Name the second file with a name that sorts alphabetically *after* your working file (I give it a name starting with Z). Switch to your working file and "prime" the Find and Replace dialogue box. Enter the following "Find what" string (without the quotes): "^#^#^#^#)". This will search for anything of the form "0000)"—in other words, something that looks like a year at the end of a citation. (You can record this set-up in a macro so you don't have to remember the code.) When it's all set up, click on "Find Next" to find the first occurrence.

When you find the first matching string, select the entire citation (e.g. "Smith & Jones, 2000"). Now run the main macro (the one I've called ReferenceSearch, as

listed below). (If you assign the macro to a keystroke, you can run it again and again as fast as you like.) The macro will copy the highlighted text, switch to the second document (it's considered the "second" document because its name comes later in the alphabet), paste the citation in, enter a carriage return, then switch back and search for the next apparent citation. All automatically.

When you've got to the end of the document, go back to the top, modify the wildcard search string to "^#^#^#^#^$)", then search again, in case there are any dates of the form "2000a". Note that if a citation is written like "2000a, b", the macro won't find it. You are welcome to improve the code.

Switch to the second document and save it.

Go through line by line and check that all citations follow the same format; e.g. multiple citations separated by "," or ";", dates of multiple citations in chronological order, "and" or "&" used consistently, etc. Correct the working file as necessary.

Use Find and Replace to break up multiple citations into one per line: replace "; " with a paragraph mark, for example. Select all, then sort alphabetically (Table: Sort: OK). Save again.

Now delete duplicates (but beware very similar entries). Finally you should have a list of all references cited that should match the References list. Compare the two lists side by side on-screen. You'll quickly see whether any citations are unreferenced or any references are uncited. (If you have a small screen and find it a bother to resize the two windows, MS Word offers a neat solution. Just go to Window: Split.)

This might sound complicated on reading it here, but it is quick and easy to use when you get the hang of it. And it makes finding reference inconsistencies simple and accurate.

```
Sub ReferenceSearch()
    Selection.Copy
    Windows(2).Activate
    Selection.Paste
    Selection.TypeParagraph
    Windows(1).Activate
    Selection.MoveRight Unit:=wdCharacter, Count:=1
    Selection.Find.Execute
End Sub
```

Appendix 2—Wordy phrases

You can reduce a lot of verbiage in most scientific reports (and in nearly all government reports!) by replacing waffly phrases with simple alternatives. This reduces the amount of words that readers must wade through to get the message (imagine a ratio of words to quantity of meaning), delivering the same message in a clearer, quicker, more economical way. (This is a worthy aim in scientific writing. But don't try it in literature, where words are carefully chosen to impart mood as much as meaning.) But take care to avoid false economy, which can lose vital meaning.

Here is a list of common terms used verbosely, pompously, occasionally incorrectly or just unnecessarily in scientific texts. Slash away at them. (Terms marked with an * are discussed in the text.)

Lengthy term	**Simpler term**
a large number of	many
additional	more, extra
adjacent to	next to, near
an adequate amount of	enough
an appropriate amount of	[state the amount]
applied*	used
as well as	and [except where it is being used parenthetically]
at this point in time	now, then
attempted	tried
causal factor	cause
compared with*	than
demonstrate	show
despite the fact that	although, even though
due to* the fact that	because, as
employ	use
endeavour	try
enumerate	count
fewer in number	fewer
impact (*v.*)	affect, influence
in a satisfactory manner	satisfactorily
in addition to	also, too [except where it is being used parenthetically]
in close proximity to	near
in order*	[usually delete]

in the case that	when
in the vicinity of	near
is known to*	[delete]
is not able to	cannot
it has been considered that	[delete]
it has been reported by X	X reported
it is interesting to note that	interestingly [or delete]
it should be noted*	note
large in size	large
prior to	before
quite unique	unique
red in colour	red
subsequent to	after
the authors	we
the majority of	most
through the use of	by, with
utilise	use
was of the opinion	believed, proposed, hypothesised, speculated

Appendix 3—British or US spelling?

Instructions to authors or publishers' instructions will usually state the flavour of English to be used, but some give a choice. Where there is a choice, sometimes it can be difficult to decide whether an author has used British or US spelling. Here is a list of shibboleths that can be used to help decide.

British	**US**	**British**	**US**
-is-, -iz-	-iz-	-wards	-ward
-our	-or	besides	beside
-yse	-yze	litre	liter
practis- (verb)	practic-	metre	meter
-lled/-lling	-led/-ling	oestrogen	estrogen
haem-	hem-	oesophagus	esophagus
-aem-	-em-	paed-	ped-
-tre	-ter	palae-	pale-
-ogue	-og	adaptor	adapter
grey	gray	non-	non‿
storey	story	manoeuvre	maneuver

Appendix 4—Unicode values and non-displaying characters

Sometimes characters that an author uses will not show up on your screen. In MS Word they are shown as underscores (_). It is necessary to know what the characters are so that you can be sure they are used correctly. So how do you find out?

The easy way is to ask the author. If you can't do that, you can try changing the typeface ("font") (try Symbol, but be aware that some journals proscribe its use, because it is automatically stripped out of submitted files). Or you can export the file from your word processor as HTML, open it in your web browser and find the character there.

If none of those solutions works, you can go "under the hood" and find out the Unicode value. (Unicode is an international system in which every single character in every alphabet in the world has its own unique code.) With that value, you can look up the Unicode character charts (see below) and insert the character in a typeface that you have (and that the author and journal are certain to have). So how do you find the Unicode value?

One way is if your word processor has a function that reveals the value of a character. For example, you can run the following macro in MS Word to see the value of any character (select the character first).

```
Sub UnicodeValue()
    MsgBox AscW(Selection.Text)
End Sub
```

The other way requires a text processor, such as TextWrangler or WordPad. First, save your file in RTF (Rich Text Format). RTF files are text only. Open it in the text processor. The text processor must be able to search on "regular expressions" ("regex"), which is the same as the wildcard search in MS Word and the grep search in Unix. Search for the following string (without the quotes): "\\u[0-9][0-9]". This will find any string of the form "\u*nn*", where *n* represents any digit. This is how Unicode characters are encoded in RTF. (Be sure that you skip the top part of the file, in which the lines all begin "{\f*nn*", and head for the text part lower down.) The surrounding text will give you an idea of where in the file the character appears.

Having found the code (up to five digits long), in the "Find what" field in your word processor search for ^u*nnnnn*. For example, ^u246 will find ö. Click on Find. The cursor should stop at the mystery character.

Now that you've got the code, how do you work out the character? In most cases, the characters will be those shown in the following table. If not, go to http://

www.unicode.org/charts/, where you can download the complete Unicode set in PDFs. Then just look up the code in the appropriate chart. (Note that the charts use hexadecimal values.) The same Web page also has a search box into which you can type the value (in hexadecimal) and it will return a link to the PDF in which the character is displayed.

Unicode character chart (decimal values)

176	°	913	Α	926	Ξ	945	α	958	ξ	8531	⅓
177	±	914	Β	927	Ο	946	β	959	ο	8532	⅔
178	²	915	Γ	928	Π	947	γ	960	π	8544	Ⅰ
179	³	916	Δ	929	Ρ	948	δ	961	ρ	8545	Ⅱ
180	´	917	Ε			949	ε	962	ς	8546	Ⅲ
181	*μ*	918	Ζ	931	Σ	950	ζ	963	σ	8547	Ⅳ
182	¶	919	Η	932	Τ	951	η	964	τ	etc. to	XII
183	·	920	Θ	933	Υ	952	θ	965	υ	9632,3	■ □
188	¼	921	Ι	934	Φ	953	ι	966	φ	9650,1	▲ △
189	½	922	Κ	935	Χ	954	κ	967	χ	9670,1	◆ ◇
190	¾	923	Λ	936	Ψ	955	λ	968	ψ	9679,5	● ○
215	×	924	Μ	937	Ω	956	μ	969	ω	9792	♀
8451	°C	925	Ν			957	ν			9794	♂

Appendix 5—Character charts in logical groupings

Macintosh characters in logical groupings o = option key s = shift key

Accented characters and ligatures

Á	oe A	á	oe a	É	oe E	é	oe e	Í	oe I	í	oe i	Ó	oe O	ó	oe o	Ú	oe U	ú	oe u
Â	oi A	â	oi a	Ê	oi E	ê	oi e	Î	oi I	î	oi i	Ô	oi O	ô	oi o	Û	oi U	û	oi u
À	o` A	à	o` a	È	o` E	è	o` e	Ì	o` I	ì	o` i	Ò	o` O	ò	o` o	Ù	o` U	ù	o` u
Ä	ou A	ä	ou a	Ë	ou E	ë	ou e	Ï	ou I	ï	ou i	Ö	ou O	ö	ou o	Ü	ou U	ü	ou u
Ã	on A	ã	on a							ı	so B	Õ	on O	Õ	on o	Ÿ	ou Y	ÿ	ou y
Å	so A	å	o a	Ç	so C	ç	o c					Ø	so O	ø	oO				
Æ	so '	æ	o '	fi	so 5	fl	so 6	Ñ	on N	ñ	on n	Œ	so Q	œ	oq			ß	o s

Miscellaneous symbols

ª	feminine ordinal	o9
º	masculine ordinal	o0
	apple	sok
◊	lozenge	sov
←	left arrow	sou *
→	right arrow	so' *
↑	up arrow	o= *
↓	down arrow	soO *

* Symbol font

Typographic symbols and punctuation

•	bullet	o8	¡	opening !	o1
©	copyright	og	¿	opening ?	so?
†	dagger	ot	¶	paragraph	o7
‡	double dagger	so7	‘ ’	quotes single	o] so]
…	ellipsis	o;	“ ”	quotes double	o[so[
—	em dash	so-	, „	quotes baseline	so0 sow
–	en dash	o-	®	registered	or
‹ ›	guillemets single	so3 so4	§	section	o6
« »	guillemets double	o\ so\	™	trade mark	o2

Diacritics

´	acute	soe
ˆ	circumflex	soi
`	grave	so`
¨	umlaut	sou
˜	tilde	son
°	ring	ok
¸	cedilla	soz
¯	macron	so,
˘	breve	so.
ˇ	haček	sot
˙	dot	oh
˝	Hungarian umlaut	sog
˛	ogonek	sox

Common maths and science symbols

Operators						Greek		
+	plus	+	∝	proportional to	om *	∂	delta l.c.	od
–	minus	o-	¬	not	ol	Δ	delta cap	oj
×	times	oy *	Miscellaneous			μ	mu l.c.	om
÷	divide	o/	∞	infinity	o5	π	pi l.c.	op
=	equals	=	∫	integral	ob	∏	pi cap.	soP
≠	not equal to	o=	‰	per mill	sor	Σ	sigma	ow
≈	approx. equal	ox	√	radical	ov	Ω	omega	oz
≥	greater or =	o.	∴	therefore	\ *			
≤	less or =	o,	·	raised dec. pt	so9			
≡	equivalent	ob *	°	degree	so8			
±	plus or minus	so=	′	minute	o4 *			
⁄	fraction bar	so1	″	second	o, *			

* Symbol font

Greek (use Symbol font)

A	B	Γ	Δ	E	Z	H	Θ	I	K	Λ	M	N	Ξ	O	Π	P	Σ	T	Y	Φ	X	Ψ	Ω
A	B	G	D	E	Z	H	Q	I	K	L	M	N	X	O	P	R	S	T	U	F	C	Y	W
α	β	γ	δ	ε	ζ	η	θ	ι	κ	λ	μ	ν	ξ	o	π	ρ	σ	τ	υ	φ	χ	ψ	ω
a	b	g	d	e	z	h	q	i	k	l	m	n	x	o	p	r	s	t	u	f	c	y	w
ϑ	φ	ς	ϖ																				
J	j	V	v																				

Currency

¢	cent	o4
€	euro	so2
ƒ	florin	of
£	pound	o3
¥	yen	oy

With thanks to Roger Jones

Windows characters in logical groupings

Accents and diacritic marks		a	A	e	E	i	I	o	O	u	U	c	C	n	N	y	Y
Acute	´ 0180	0225	0193	0233	0201	0237	0205	0243	0211	0250	0218					0253	0221
Caron (s only)	š Š 0154 0138																
Cedilla	¸ 0184											0231	0199				
Circumflex	ˆ 0136	0226	0194	0234	0202	0238	0206	0244	0212	0251	0219						
Diaeresis	¨ 0168	0228	0196	0235	0203	0239	0207	0246	0214	0252	0220					0255	0159
Grave	` Ctrl-`	0224	0192	0232	0200	0236	0204	0242	0210	0249	0217						
Macron	¯ 0175																
Ordinal (m/f)	º ª 0186 0170																
Ring	°	0229	0197														
Slash	/							0248	0216								
Tilde	~ 0126	0227	0195					0245	0213					0241	0209		

Typographical symbols		Normal	Symbol*
Bullet	•	0149	
Copyright	© ©	0169	0227
Dagger	†	0134	
Double dagger	‡	0135	
Ellipsis	…	0133	
Em-dash	—	0151	
En-dash	–	0150	
Paragraph	¶	0182	
Registration	® ®	0174	0226
Section	§	0167	
Trade mark	™ ™	0153	0228
			*sans serif

Ligatures				
ae	AE	æ	Æ	0230 0198
oe	OE	œ	Œ	0156 0140

Non-English items		
Baseline quotes	„	, 0132 0130
German ss	ß	0223
Guillemet double	«	» 0171 0187
Guillemet single	‹	› 0139 0155
Inverted !	¡	0161
Inverted ?	¿	0191

Maths/science (common)		Normal	Symbol	
Degree	° °	0176	0176	
Division	÷	0247		
Equal approx.	≈		0187	
Equal/greater	≥		0179	
Equal/less	≤		0163	
Equal not	≠		0185	
Equivalence	≡		0186	
Fraction	⁄		0164	
a quarter	¼	0188		
a half	½	0189		
three-quarters	¾	0190		
Infinity	∞		0165	
Integral	∫		0242	
Minute (prime)	′		0162	
Multiplier dot	·	0183		
Multiply	×	0215 ×	0180 ×	Note the difference.
Partial differential	∂		0182	
Per thousand	‰	0137		
Plus/minus	± ±	0177	0177	
Proportional	∝		0181	
Radical	√		0214	
Second (double prime)	″		0178	
Summation	∑		0229	
Therefore	∴		092	
Vertical bar	|	0124	0124	

Greek alphabet (Symbol font)	alpha	beta	gamma	delta	epsilon	zeta	eta	theta	iota	kappa
	α A	β B	γ Γ	δ Δ	ε E	ζ Z	η H	θ Θ	ι I	κ K
	097 065	098 066	0103 071	0100 068	0101 069	0122 090	0104 072	0113 081	0105 073	0107 075
	lambda	mu	nu	xi	omikron	pi	rho	sigma	sigma 1	tau
	λ Λ	μ M	ν N	ξ Ξ	ο O	π Π	ρ P	σ Σ	ς	τ T
	0108 076	0109 077	0110 078	0120 088	0111 079	0112 080	0114 082	0115 083	086	0116 084
	upsilon	phi	phi 1	psi	chi	omega	omega 1			
	υ Y	ϕ Φ	φ	ψ Ψ	χ X	ω Ω	ϖ			
	0117 085	0102 070	0106	0121 089	099 067	0119 087	0118			

If you find this table useful, please give a couple of your local currency units to your favourite charity.

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Most of the following books grace my shelves. The rest are recommended by scientific editors who contributed their favourites to Writing: Books and Reference Sources, by John Renish, available in full at http://www.prc.dk/user-friendly-manuals/ufm/books.htm.

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Worldwide Web resources

If you have a permanent broadband connection to the Internet, you can check any fact in a matter of seconds. I do this several times through a job—there's no excuse not to check something doubtful. I rely mainly on the following handful of resources, which can in turn lead to other resources.

Google: http://www.google.com/
One Look Dictionary Search: http://onelook.com/
PubMed (for medical publications): http://www.ncbi.nlm.nih.gov/entrez/
Agricola (agricultural publications): http://agricola.nal.usda.gov/
ITIS (scientific names): http://www.itis.usda.gov/
Getty Thesaurus of Geographic Names: http://www.getty.edu/research/conducting_research/vocabularies/tgn/index.html

Software

A few programs are invaluable to me in my work. I use all of the following and would be lost without them.

Conversion. This converts just about any set of units you can think of. Mac and Windows shareware. http://rj-graffix.com/
GraphicConverter. This will open nearly any graphic file format, well over a hundred, and offers basic drawing tools as well. Mac shareware. http://www.lemkesoft.com/ (On Windows, try IrfanView at http://www.irfanview.com/)
PopChar. Unobtrusive pop-up menu that displays every single character available in the current font in the current application, then inserts your choice. Mac and Windows shareware. http://www.ergonis.com/
StuffIt Deluxe. File compression software. Every file compression format is supported. Mac, Windows and Linux commercial ware. http://www.stuffit.com/

StuffIt Expander. Expands every file compression format. Mac and Windows freeware. http://www.stuffit.com/ (Note, however, that the Windows version has received poor reviews. To avoid problems, Mac users should send .zip files to non-Mac users.)

TextWrangler. A full-featured text editor. Mac freeware. http://www.barebones.com/ (Windows offers WordPad. Mac OS X offers TextEdit, but TextWrangler is better.)

WatchIT. Essential time-tracking software for client billing. Mac commercial ware. http://www.hi-resolution.com/ (Windows users can choose from dozens of time trackers at http://www.tucows.com/Windows/Business/Management/TimeResourceManagement/)

Index

W

Z

Subtleties of Scientific Style fills the gaps left by other style guides and books on editing. Here, Matthew Stevens, an Australian scientific editor, distils over two decades of experience, explaining subtle but significant errors that authors can make and many subtle tricks that can make a work more readable. Topics include:

- Common errors—danglers, fillers, misapplied modifiers, shortcuts
- Errors of reasoning—begging the question, teleology, size comparisons
- Expression—first-person science, order of events, parallel narratives
- Tricky terms—applied, based on, due to, respectively

And two handy character charts for Macintosh- and Windows-based editors who are tired of hunting around for special characters.

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