A Guide to Science Writing

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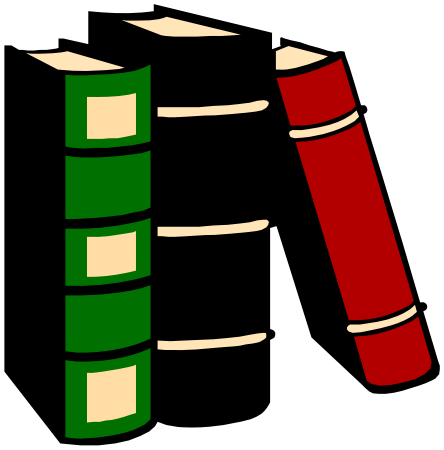

Documents	Grant applications
	Scientific papers
	Literature reviews
Approach	Planning
	Reviewing
Writing	Title
	Abstract
	Introduction
	Materials and Methods
	Results (+ Tables + Figures)
	Discussion
	References
Editing	Paragraphs
	Sentences
	Words
	Punctuation
Submission	Editors

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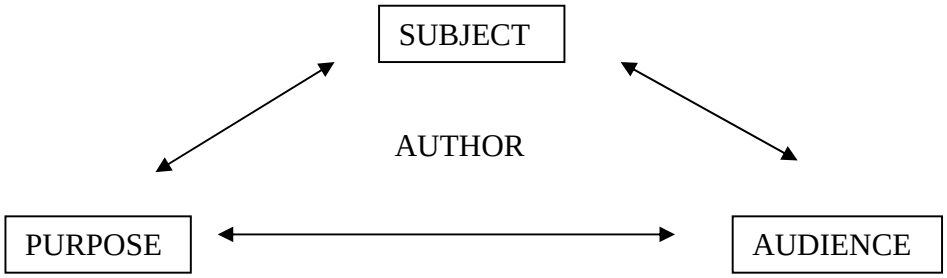
SCIENCE WRITING

Whatever you are writing, you need to bring together writer, subject, purpose and audience. You (the writer) have something you want to say about an incident, person, problem or idea (subject) for a particular reason (purpose) to one or more people (audience). This constitutes the "communications triangle" (Ebbitt, 1982).



Scientists are called upon to write 3 main types of documents:

- grant applications;
- scientific papers; and
- literature reviews.

While the instructions given to authors by granting agencies, publishing houses and editors may differ, there are many common elements to these documents. All three are subject to peer review by independent referees to gauge integrity and quality, they generally adhere to a 'scientific' format (IMRAD = Introduction, Methodology, Results and Discussion), and they are mostly written in formal language (third person passive). Scientists conform to prescribed formats to get material published and they write for other scientists, rather than for the community at large. The growing demand to revise and broaden science communication has created jobs for science writers and knowledge brokers, third parties who are not science specialists but are trained communicators able to simplify and explain science to society.

Grant applications

Governments make funds available each year for scientific research, often in applied priority areas. Various schemes have been developed for project grants, industry partnerships, exchange programs, cooperative research, institutional programs, etc. Securing funds is a fierce competitive process, with significant employment and career consequences. Individuals and organizations invest considerable resources in applying for grants but regrettably, the success rate is low (15-25%). It is, however, the only game in town, so every scientist plays. Grant applications require a catchy title (strong focus), a succinct summary (intelligible to laypersons), specific aims and objectives (logical and contextual), statements of expected outcomes (relevance and impact to society, industry, etc), an itemized budget (with justifications for expenditure) and finally, the actual project proposal (background, methodology, timetable). Applications are reviewed by independent referees, ranked according to specific criteria, and funded expediently (offers made until money runs out). Scientists are often judged on two criteria, grantsmanship (money-in) and authorship (papers-out).

Scientific papers

Libraries are filled with thousands of volumes of scientific journals which contain millions of scientific papers. Most journals are thematic and cater for specific disciplines and audiences. They vary widely in their distribution and availability, roughly half being parochial (regionally specific) and the remainder being international. Scientists submit manuscripts to the journal editors who then send them to independent referees for review.

Articles may be rejected for many reasons (badly written, inexact science, falsehoods, not in context of journal, etc) or accepted for publication after major, minor or no revision. Few journals are free to the authors; most have page charges or reviewer fees. Even with the recent trend towards on-line editing and publishing, there are still fees payable to publishing houses.

Scientists generally write two types of scientific papers: full research papers; or short contributions. Both follow an almost universal prescribed format: title (sufficiently descriptive in its own right), abstract (summary of whole paper), Introduction (background and objectives), Methodology (materials and methods used), Results (observations and experimental findings), Discussion (critical interpretation in context) and references (other works cited).

Short communications are condensed versions of full papers. Scientists spend inordinate amounts of time crafting the abstracts of their papers because they are reproduced in scientific databases and search engines, and are often the only thing other scientists read.

Literature reviews

Due to the overwhelming number and diversity of publications available, many publishing houses now organize and publish literature reviews as journal articles, book chapters, and even whole books. Most reviews are commissioned articles whereby the authors have been invited to prepare and submit a treatise on a particular topic.

The reviews can be critical analyses of contemporary issues, historical summaries of developing fields, personal opinion pieces, or collations of relevant resource materials (databases, catalogues, bibliographies, checklists, etc). Literature reviews provide an ideal starting point for novices to be introduced to a topic. Indeed, all higher degree students are required to write literature reviews to provide background and perspective to their research projects. Professional scientists use reviews to keep apace with recent developments and the authors achieve elevated status as recognized world authorities in the relevant field.

Reviews follow various formats, but essentially they rationalize their existence (justify objectives), summarize previous studies (compare and contrast, pros and cons) and suggest future directions for research.

Approach to writing

Scientific writing can be quite different from other forms of writing, but like all generic skills, it gets better with practice. Many scientists state that their major obstacles to writing are:

- over-justification syndrome (trying to qualify everything),
- exception syndrome (making generalizations but becoming bogged down with all the exceptions to the rule),
- forest-from-trees-syndrome (failing to properly identify scope and content of article),
- beginner's block (where to start) and
- common old writer's block (procrastinate - do something else instead).

Successful writers have identified two strategies that they consider to be exceptionally helpful: doodling on paper (planning) and talking out-loud (reviewing).

Planning

Students often immerse themselves in topics without having developed any writing plan of their own. They quickly become buried in the information overload, often focus on irrelevant items, and become confused by other people's ideas, which are often contradictory. Everyone must develop a plan of attack for the job ahead, whether it is making a shopping list, a holiday itinerary, or a scientific paper. The best place to start is with a blank piece of paper. Your mind is already mulling over the task ahead and many connections are already being made consciously as well as subconsciously. Writing down those thoughts and ideas whirling through your mind brings structure to your work by identifying scope, sequence and schedule. A similar strategy often employed in tutorial classes is known as concept-mapping. The advantage of using pen and paper to begin with, rather than word-processing computer packages, is that handwritten scribbles are psychologically less daunting and less prescriptive than pretty organized typed text on a computer screen. Many writers consider using paper to be vital to the brain-storming creative process while keyboards (type-writers and computers) help polish and present product. Simply jotting down main elements in the form of headings (keywords or phrases) allows the writer to identify relevant content, distill the essence of the paper, break down a big onerous task into smaller do-able items and actually begin the task. Subsequent re-arrangement of the headings allows the writer to develop a logical train of thought and provides the framework for the story to be told. Having planned the task and identified the cognate components, writing the rest of the paper is simply a matter of adhering to the plan, filling in the gaps and word-smithing.

Reviewing

An excellent strategy used by many authors is to read their sentences out-loud. Humans have much better verbal skills than writing skills because speaking is the most commonly practiced form of communication and uses much simpler language than written text. Many people advocate the KISS principle (keep it simple, stupid!). Listening to yourself can bring life to the topic, help moderate language and grammar, de-convolute long complicated sentences, and streamline textual flow. Reading it out loud to someone else has the added advantage of involving an audience and obtaining critical feedback (hopefully constructive rather than destructive).

WRITING GUIDE

The IMRAD sequence has been adopted as an International Standard for reporting experimental science. It is not appropriate for all papers (e.g. reviews) and not all disciplines follow it exactly. Nonetheless, it provides an extremely useful template for organizing material.

Sequence of research	Format and Content	Elements of critical argument
the question to be answered	INTRODUCTION	the problem (question)
how the answer was sought	MATERIALS & METHODS	credibility of evidence
findings of study	RESULTS	evidence (data), initial answer
findings considered in light of other work; the answer	DISCUSSION	supporting/contradictory evidence; assessment; answer

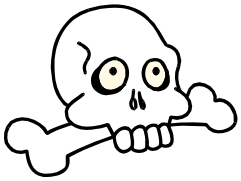
Many authors use a 'hierarchy of headings' to organise outlines of their work, using headings to logically arrange broad general categories and informative subheadings to organise narrower specific subcategories. Strategies used include writing headings (logical categories) on separate pages, listing subheadings in point-style form, identifying keywords within subheadings, and arranging (and re-arranging) material using post-it notes or other cut-n-paste contrivances. Having planned the basic structure and draft content of the paper, it is then important to actually write draft narratives for subheadings. Try writing incrementally – in bits as you go along.

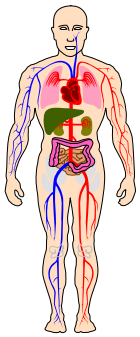
There are many tips for writing first drafts of papers, including:

- choose your best time to write (when you are alert, not tired)
- choose a suitable place (comfortable conditions free of distractions, annoyances)
- tackle the easiest, most factual, sections first
- write quickly to keep your ideas flowing (do not break flow to check material)
- do not worry about spelling, expression or typing mistakes (they can be edited later)
- if you get stuck, drop it and tackle another part (keep putting things down on paper)
- double-space your text (it is more conducive to creativity and easier to edit)
- take a break after about 60 minutes (30 minutes for top concentration)
- writer's block – come back to the problem later.

There has been an explosion in the number of books available as guides to scientific writing. Many profess to be comprehensive and inclusive, even providing templates for budding authors to follow. Regrettably, science communication has not been standardized internationally. Although individual journals and book publishing houses prefer particular styles (available as itemized *Instructions to Authors* on request), they vary from place to place, and even from time to time. The IMRAD format is probably as close to a universal system as we will come, but with many variants. Nobody wants to stifle the creativity and intellectual freedom shown by our authors by demanding adherence to a single rigid format. I liken the creative process of writing scientific papers to using Frankenstein's guide to building a body of knowledge: start with an assortment of bones (relevant items); construct a skeleton (logical framework); flesh it out (add substance); and dress it up (language).

Frankenstein's Guide to Scientific Writing






gather bones	assemble skeleton	flesh it out	dress the body
- identify key components - back-engineer title	- provide logical structure, e.g. - table of contents paragraph headings	- identify specific content - subheadings keywords	- write connecting text - grammar punctuation
Planning phase	Construction phase		Writing phase

A systematic parametric approach to writing not only breaks huge tasks into smaller do-able components, but it also forces you to constantly revise content and sequence. The IMRAD headings provide an ideal starting point for budding authors. The following paragraphs provide information about the content and purpose of the IMRAD headings, followed by helpful hints about grammar and expression.

Title (What is the paper about?)

Describe the subject of the paper in the fewest possible words. Make it concise, accurate, informative and interesting. Remember that the words used in the title act as keywords in searchable computerized databases. Avoid abbreviations and acronyms as they can be variably interpreted. Cut out 'waste' words (e.g. 'the', 'of', 'on'). Do not put a full-stop at the end (a title is not a sentence). The objective of the title is to convey not only the discipline or field of study but also the thrust, direction or essence of the research.

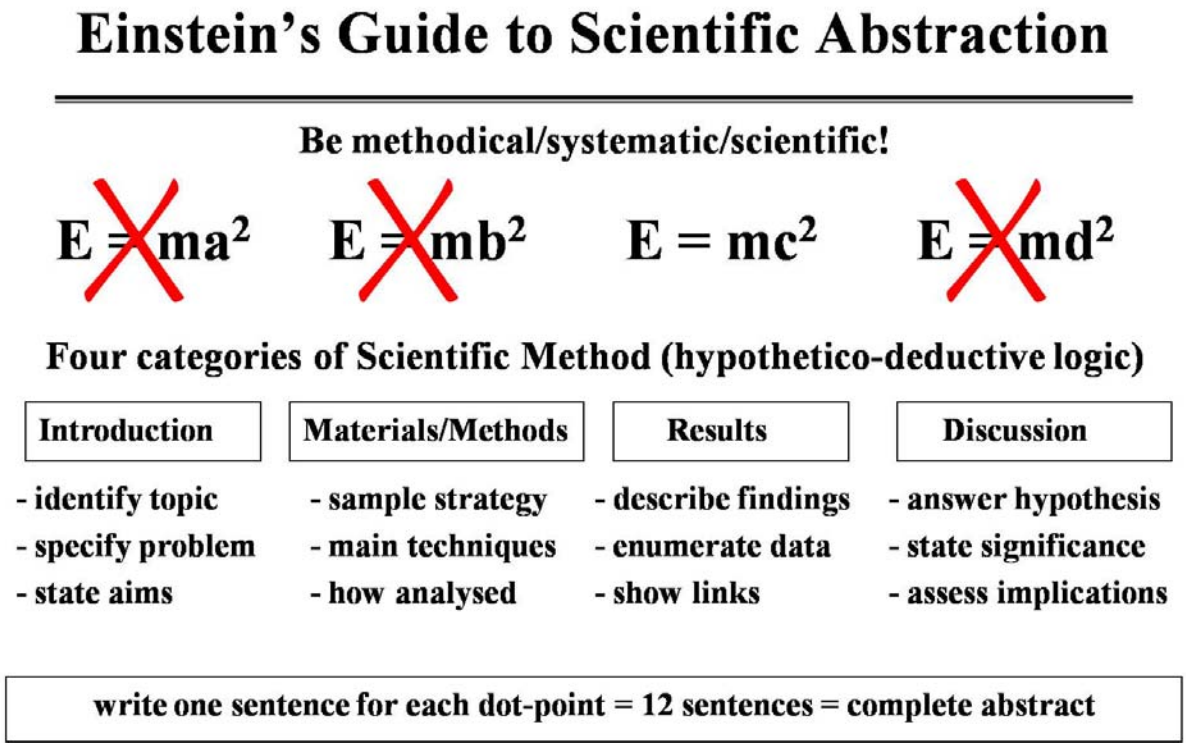
Titles generally follow one of three patterns:

1. summary of topic (e.g. "*Comparison of parasitic infections of sheep and goats in Wales*")
2. summary of findings (e.g. "*Goats have fewer parasites than sheep in Wales*")
3. subject/topic: aspect examined (e.g. "*Parasites of sheep and goats: prevalence in Wales*")

Abstract (Summary of paper)

Few people will ever read the whole text of your paper, but many more will read your abstract to glean information (or decide to read the remainder). Indeed, indexing journals and computer data-bases provide virtually instant access to scientific abstracts. The abstract must stand alone. The information contained must be designed to catch the reader's attention. It should summarize the principal objectives, scope of investigation, main results, principal conclusions, and implications of your findings. Be informative rather than descriptive. Keep sentences short and simple, one topic per sentence. Do not repeat or paraphrase the title. Try to emphasise the different points in proportion to the emphasis they receive in the body of the paper. Do not use unfamiliar terms, acronyms, abbreviations or symbols. Do not cite other work.

Many authors mistakenly try to justify their study in the abstract and provide few details of the work actually performed. Others provide comprehensive results but do not interpret their significance. The abstract must be a compilation of the main points of the whole investigation. Write and edit several drafts of the abstract as it can help you focus on the main points you wish to communicate. Most journals set a word limit for the abstract. Use it all wisely! In an attempt to better standardize and regulate content, some journals have recently introduced structured abstracts (prescriptive templates with subheadings such as Aims, Methods, Results, and Conclusions). Try using headings when writing (you can cut them out later).



Introduction (Background and objectives)

This section should establish not only the problem under investigation but also the relevant background, who/what is affected, what progress has previously been made and briefly what you did. It is a good place to define scientific and technical terms, and some journals even like you to give the main result. The purpose of the Introduction is to supply sufficient background information for the reader to understand and evaluate the results of the paper without needing to read previous publications. You must state the question being addressed but be careful when using the word '*hypothesis'* as it has a specific scientific meaning but is variably interpreted by editors, referees and readers.

Good introductions often fall into three parts.

1. The first states the general field of interest.
2. The second presents, in main lines only, the findings of others that will be challenged or developed.
3. The third specifies the question to which the present paper is addressed. The third part may indicate by which means the question has been examined, especially if the methods are new or unfamiliar, and may or may not state the conclusions.

The aim throughout should be to excite and interest the reader and answer the question: 'Why was this work embarked upon?' " Anon. 1986 "Scientific Writing for Graduate Students"

Materials and Methods (What was used? How?)

The main purpose is to enable readers to understand how you gathered your data so they could repeat your experiments or compare studies. First describe the experimental design or theoretical approach. State what assumptions you made in designing the experiment. Use subheadings to arrange information (where possible, 'match' subheadings in the Results section).

> Describe the materials precisely and concisely (giving all essentials). Describe geographic areas; include map, with place names, latitude and longitude (no compass point if map is oriented north). Give full taxonomic identification, including source, strain, breed, cultivar or line (give authority for nomenclature). Give characteristics of your sample (number, age, weight, sex, etc).
>
> Describe the methods in logical order and include enough details for reproducibility. If you used a previously published method, refer to it rather than repeat it (but note any modifications). If you have used a new method, describe it in full. Explain any validation or standardization of test procedures (including numbers of replicates, positive and negative controls, and test-to-test variation). Describe experimental conditions using conventional scientific annotation (nevertheless, give compound abbreviations and acronyms in full at first mention). Provide details of all analytical techniques used; stating exactly which statistical tests and computer programs were utilized. Include any criteria used to interpret data.

Results (What were your findings?)

Having conducted your investigation, you need to summarize, analyse and present your findings in a logical coherent fashion. Remember that the results should stand alone as text, and only be supported by tables and figures as required for illustrative purposes (it is never sufficient to say the results are shown in Table X). Use draft tables and figures to decide upon the best order to present your results, beginning with the main findings and scaling down to subordinate material. Write the text independently of the illustrations, and then decide which ones deserve inclusion as supporting material (usually you will generate many more figures and tables than can be included so you need to make judicious choices). Do not repeat figure or table legends in the text. Exclude irrelevant results, but do not suppress valid results that appear to contradict your hypothesis (use the discussion to explain the anomaly). Make it clear how your results relate to your argument. Remember to be quantitative rather than qualitative by enumerating data and completing comparative phrases (e.g. "infections were more prevalent in winter" is less clear than "infections were more prevalent in winter (75%) than in summer (50%)". Include the statistical significance of differences where appropriate, showing test and probability (e.g. $F = 2.34$, $p = 0.04$). State the number of measurements (e.g. $n = 120$) and use standard deviation to show variability among individuals, while standard error shows the precision of the sample mean. Do not attempt to validate, interpret or discuss your findings in the results section, simply report the facts.

Tables (rows by columns): Use tables wisely - they do not supplant text, and they should not present raw or complex data sets. Instead, they should provide clear guides to data summaries or trends. Because you present material in neighbouring columns and/or rows, they are ideal for comparative purposes. Do not clutter them by using too many lines, grids, fancy borders or shading (avoid default styles in computerized package). Follow the style guides given by the journal instructions to authors (or copy styles they have used previously). Refer to the table in the text before giving the table. Ensure that the legend is accurate and succinct (preferably explain any abbreviations in footnotes). Give numbers to an appropriate degree of accuracy (do not imply greater precision than you achieved with your measurements).

Figures (graphs, charts, maps, drawings, photographs): Authors use figures for a variety of purposes: as visual aids to the understanding of complex concepts, proof of existence, summaries of analyses, stylistic renditions of complex or cryptic entities, or simply as representative illustrations of items, places or procedures. They are best used to present data for which trends or proportions are important characteristics. They do not supplant text and should not be used as subject or object within sentences (best included as ancillary material): e.g. rather than saying "*Fig. 5 shows infections lasted 20 days*", say "*Infections lasted 20 days (Fig. 5)*". Graphs should not contain too many lines (norm is 3 to 4 curves) and all axes should be scaled and labelled (including units). Make sure the reader can discriminate between individual plots by using contrasting lines and/or data-points. Avoid colour unless it is the norm for the journal (bear in mind that most journals charge authors for colour reproductions). Make sure photographs clearly show intended features and use annotations to highlight items.

Discussion (What does it all mean?)

Many writers introduce their work satisfactorily, describe their methods adequately and arrange their results in logical order, but become overwhelmed by the Discussion section. To some, this all-inclusive heading is an invitation to wax verbose, to expound at length and in detail, and perhaps pontificate a bit. A frequent fault is the verbatim or nearly verbatim repetition of statements from the Results section, which the authors believe to be necessary to formally bring up each topic for discussion. A special example is provided by the converted thesis, in which the writer successively examines various possibilities in detail and then in equal detail shows how they could not possibly apply to the work at hand. The result is a distinctive roller-coaster pattern that offers no informed or constructive critical interpretation of material. No panacea is offered here. The Discussion is often the most difficult section to prepare and calls for careful thought and concise, coherent composition.

Make sure you answer the question(s) stated in your Introduction (try using the end of the Introduction as your starting point). Discuss, but do not recapitulate, your results. Provide contextual relevance not only within your field of study but also within a broader scientific context. Make it comparative by showing how your findings and interpretations agree (or contrast) with previously published work. Do not shy from critical interpretation, but be constructive rather than destructive. Distinguish between facts and speculation. Use the past tense for results and the present tense for general statements. Discuss the theoretical implications as well as the practical. State your conclusion(s) as clearly as possible. Indicate where the work could go next (but avoid the clichéd "*Further research is required*")

References

Plagiarism comes from the Latin for kidnapper. By 1646 it referred to literary theft, passing off someone else's words and thoughts as one's own. Make sure you cite relevant references in the text when including someone else's work (whether quoting, paraphrasing or simply mentioning it). Widely known facts or ideas do not need a reference (e.g. "*Many worms are parasites*"), whereas facts that are not common knowledge do (e.g. "*Necator is a parasitic worm (Smith, 2005)*"). Pay scrupulous attention to the style and accuracy of all your references (in text and listed at end) because the journal referees and editors will (most making the assumption that sloppy referencing is indicative of sloppy substandard work).

Cite references in the text as follows - one author: Smith, 2005; two authors: Smith & Jones, 2005; three or more authors: Smith *et al*., 2005. My pet-hate is the inappropriate use of *et al*. (Latin for *et alia* meaning 'and others'). Include only those references cited in-text in the List of References (it is not a bibliography). Follow the citation format recommended by the journal (most use an International Standardized List of Periodical Abbreviations).

Editing

The first draft of your manuscript is complete . . . your co-author, manager or supervisor has asked to have a look. *REFUSE!*

If your first draft is like most first drafts, you will get it back full of despairing red ink; you will have established your reputation as a bad writer. No matter how clearly you tell people "this is only a rough draft", they will treat it as a final draft. Do not give your manuscript to anyone until you have finished editing it for structure and style.

It is very difficult to read any paper to check its content, structure and argument and at the same time check its grammar and expression – the first requires you to step back and take a broad view; the second requires detailed word-by-word study. So you will have to edit at least twice to do a good job (most authors go through 4-5 drafts to craft their manuscript before submission, and still be required to revise portions before acceptance for publication).

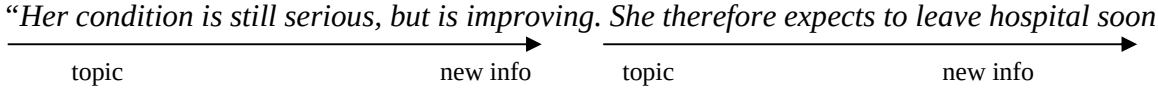
There are many tips for editing manuscripts; including the following step-wise approach:

1. Put your first draft away for several days (return to it with fresh eyes)
2. Print your manuscript double-spaced and work on the paper copy (forget about editing on screen).
3. Read it out loud
4. Compare your tables with each other; do the same for the figures (checking for consistency in style and accuracy).
5. Edit for content, structure and argument ("structural editing")
6. Edit for grammar and expression ("stylistic editing")
7. Finish it off by checking tedious details (e.g. referencing)
8. Give it to people to read.

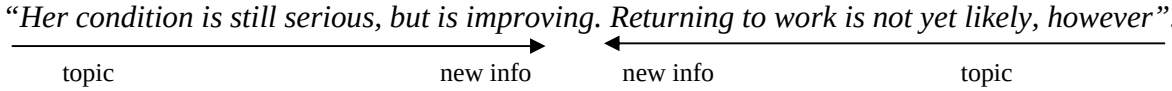
Beware computerized spelling and grammar checkers – they include many versions of English dictionaries (most defaulting to American versions).

I have a spelling checker
It came with my PC
It plainly marks for my revue
Mistakes I cannot sea.
I've run this poem through it,
I'm sure your please to no,
Its letter perfect in it's weigh,
My checker tolled me sew.

Paragraphs are units of thought, not units of length; "one idea – one paragraph". They offer readers manageable segments of information, give visual clues to the transition between thoughts or ideas, and provide pauses to absorb information. The first sentence of a paragraph usually tells you what the paragraph will be about (= topic sentence). The rest of the paragraph expands on the topic and the last sentence rounds it off (it can also be a connecting sentence pointing to where the next paragraph will be going). If you simply read out loud the first sentences of every paragraph of your paper, and still understand the crux of the paper, you have done a good job. Avoid jerky paragraphs. The sentences should hang together so the reader progresses smoothly through the paragraph. Continuity is best provided by using two characteristics of English sentences: noting that the stress positions of a sentence are at the beginning and end; and using this to place the topic of the sentence at the beginning and new information at the end; e.g.
-continuous flow:



-discontinuous flow:



Sentences fall into one of six patterns (remember that an 'independent clause' is one that could stand alone as a sentence, a 'dependent clause' cannot).

1. Simple sentences have one independent clause containing a subject and a verb, and sometimes also an object or predicate adjective. Used to make an unqualified observation; e.g. "*The door leads to the garden*".

2. Compound sentences have two or more independent clauses joined with a comma or coordinating conjunction (*and, or, but, for, nor, so, yet*), a semicolon, or a semicolon and coordinating adverb (*however, therefore, this, moreover, nevertheless*). Used to make two (or more) unqualified observations, often in comparison and contrast; e.g. "*The door leads to the garden, but it is hard to open*".

3. Complex sentences contain one independent clause and one or more dependent clauses (which act as qualifiers). Adds a qualification or subordinate idea to an observation; e.g. "*Although the door led to the garden, she could not open it*".

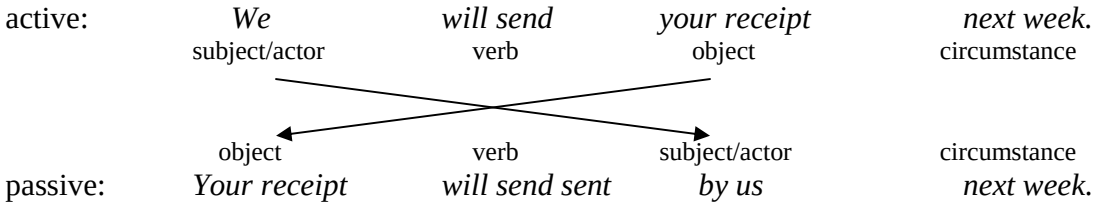
4. Compound-complex sentences have at least two independent clauses and one dependent clause. Presents two primary observations, one or both of which are qualified; e.g. "*She could not open the door to the garden, it was made of iron and had rusted shut*".

5. Exclamations are short sentences that may be calls, shouts, utterances, interjections or imperative commands; e.g. "*Shut that door!*"

6. Questions are sentences addressed to a person in order to prompt an answer (actual or rhetorical); e.g. "*Who said that?"*

As a general rule, you should follow the "subject-verb-object" (or "topic-verb-new information") pattern for constructing sentences. Put the topic at the beginning, less important information in the middle and "new" information at the end of the sentence. Avoid upside-down and inside-out sentences; such as, "*Have the students make mobiles, and then hang them in the classroom*" or this classic from the Brisbane Courier-Mail "*A section of wing fell off a 747 on a flight from Manila to San Francisco on March 25. It returned and landed safely at Manila*".

Most science is written in passive rather than active voice. Writing in the active voice does not necessarily mean using the first person (singular *I* or plural *we*). There are lots of other actors (or agents): e.g. passive voice "Spectroscopy *was used to determine* the position .", active voice "Spectroscopy *determined* the position ."). Regardless, if a sentence is less awkward with *I* or *we* as the agent, use it (albeit sparingly). Most journals now regard prohibitions against first person active as out-dated, but most papers still only contain a few of these pronouns. Passive voice reverses the natural sentence order, so is less straightforward. Scientists often prefer passive voice because it need not state the agent, gives an air of objectivity, and sounds authorative. Regrettably, it can lead to grammatical mistakes, dull prose, misunderstanding, ambiguity, circumlocution and longer sentences. Unfortunately, passive voice becomes a habit, and writers use it relentlessly.



Avoid inordinately long sentences as they tend to confuse issues rather than clarify them. Make sure the logical train of thought you want the reader to follow is transparent and obvious. Use concise focussed sentences to do so (KISS principle!). Use parallel structures to organize information (parts of a sentence similar in meaning should be similar in construction): e.g. rather than stating "*The prevalence in the Australian sample was 25% and 30% in the New Zealand sample*", say "*The prevalence in the Australian sample was 25% and that in the New Zealand sample was 30%*". If you carefully establish a pattern that the reader expects you to continue, do not break it without good reason. Do not be afraid to repeat words, phrases or even sentences. Repeating is better than confusing. Many of us are taught to make our writing "more interesting" by using synonyms, paraphrasing, or saying it another way. There is no place for elegant variation in scientific writing! Do not force the reader to back-track to find meaning. Avoid transpositional instructions like "*as previously described*", "*stated earlier*", and even "*respectively*". "*Former*" and "*latter*" can be used with only two items; use "*first*", "*second*", "*third*" / "*last*" with more items, but do not tax your reader.

Word choice is critical. Stick to plain, not posh, English. Choose plain words your readers are likely to understand (simple nouns, lively verbs, clear adjectives): e.g. "*Keep up your bright swords, for the dew will rust them*" rather than "*Relinquish your luminous armoury, for the atmospheric moisture would cause its deterioration*"). Proper nouns pose few problems, except when they are coupled together to form long noun strings (avoid compound nouns, or hyphenate them for clarity).

Abbreviations and acronyms ("alphabet soup") should only be used if they are generally known (e.g. WHO = World Health Organization) or common in specific fields (in immunology, CFT = Complement Fixation Test). Beware excessive jargon, you might end up with whole sentences (e.g. ELISA PAGE AIDS FISH = Enzyme-Linked Immuno-Sorbent Assay, Poly-Acrylamide Gel Electrophoresis, Acquired Immuno-Deficiency Syndrome, Fluorescent In Situ Hybridization).

Abstract nouns refer to qualities, states or actions (e.g. *honesty*, *knowledge*, *destruction*). We cannot do without them, but far too often they are simply smothered verbs. Many abstract nouns made from verbs end in *–ment, -tion, -sion* or *–sis* (e.g. "*acquisition"* is the noun, "*acquire*" is the verb). Sentences can be simplified by uncovering these verbs; e.g. "*The addition of X made an improvement to Y*" can be simplified to "*Adding X improved Y*"). Too many words can lead to windbaggery. Cut out the empty words. The italicized words in the following examples can be deleted: elliptical *in shape*; fewer *in number*; green *in colour*; in *the month of* June; research *activity*. We also use many phrases where a single word would suffice; e.g. change "*owing to the fact that*" to "*because*"; change "*as regards the matter of*" to "*about*".

Many words in the English are derived from other languages, and may have unusual plural forms: e.g. singular/plural = *datum/data, agendum/agenda, genus/genera, criterion/criteria, larva/larvae, phenomenon/phenomena, medium/media, memorandum/memoranda, bacterium/bacteria, curriculum/curricula, maximum/maxima, ovum/ova, operculum/opercula*. Other words use the standard English plural (adding an *s* or *es*) e.g. *hippopotamuses, prospectuses, platypuses, apparatuses, forums* (in the 1980s, *fora* became fashionable, despite it having been *forums* since 1460 – I have even come across *foras*). Other vacillate, usually depending on a difference in meaning (e.g. *appendices* in books, *appendixes* in the body; *indexes* in books, *indices* in mathematics) or on a whim (e.g. *aquaria* or *aquariums, referendums* or *referenda*).

If you are unsure of a word (its spelling or more importantly, its meaning), either do not use it, or look it up in a dictionary (one relevant to your brand of English). Words that are commonly mis-used/mis-spelled include:

- *complement* (completes, add to) v. *compliment* (flattering expression)
- *effect* (bring about) v. *affect* (change in some way)
- *principle* (idea, theory, basis) v. *principal* (chief, main)
- *proceed* (go forward) v. *precede* (go before)

Punctuation began with the Greeks, who used it to break up written text into discrete units of thought or argument (they did not split up words with spaces because the word endings indicated the end of the word, and their lines of text often ran in alternate directions). If an ancient Greek had been writing modern English, the opening of the American Constitution would have looked like this:

REDRONISETATSDETINUEHTFOELPOEPEHTEW
TOFORMAMOREPERFECTUNIONESTABLISH

Punctuation was developed to help people read out loud; in previous centuries, sentences had lots of commas and dashes to indicate pauses. We seldom read out loud now, so the modern method is to punctuate only where necessary for logic.

> "*In conversation you can use timing, a look, inflection, pauses. But on the page all you have is commas, dashes, the number of syllables in a word. When I write, I read everything out loud to get the right rhythm. [Fran Lebowitz]*

The full-stop (.) marks the end of a sentence.
It signifies to the reader to take a pause to consider what has been read before moving onto new ideas or thoughts. Do not use it after phrases (such as titles and headings).

The comma (,) marks off discrete sections of a sentence.
It parcels up the bits that belong together and keeps them apart from the bits to which they do not belong. Commas help the reader follow your thinking.

Use commas:

- before and after any element (e.g. a dependent clause, a comment) that interrupts the sentence: e.g. "*The water was, however, quite drinkable*".
- before and after a clause or a phrase that gives more information about the noun it follows: e.g. "*The mole, which spends nearly all its life underground, has very poor vision*".
- two separate clauses linked by a conjunction (e.g. *and, as, but, for, or*) when the first clause is long or the comma is needed to avoid ambiguity. e.g. "*When John left, the house was locked up securely"*.

Do not use commas:

- before (or on either side of) a clause that defines and restricts the noun it follows: e.g. "*Consider the Pei matrix that is positive definite*" asks you to focus on one matrix from among several, whereas "*Consider the Pei matrix, which is positive definite*" gives additional information about that specific matrix [Tip: if it needs a comma, use *which*].
- between independent clauses (i.e. sentences); use a full-stop (or a semi-colon). e.g. the comma in the following sentence should be replaced by a full-stop "*They could not go on, the road was blocked by a fallen tree*".
- between the subject and the verb (even if the subject is very long). e.g. the comma in the following sentence should be deleted "*Increased turbidity due to high levels of suspended solids or algal blooms and shading due to excessive epiphyte growth, are suggested as causative factors*".

The colon (:) indicates the concept "as follows".
Information provided after the colon amplifies or explains what came before. If used to introduce a list, you need not add a dash. Do not start the word after the colon with a capital letter (common in some publishing houses, especially in the USA).

e.g. "*You should remember one thing: do not fool with acid*".

The semicolon (;) both separates and combines.

Use it to:

- join two closely related sentences ("independent clauses") when you want to show the two sets of keywords are balanced or mirror each other. It creates a kind of suspended pause (a full-stop would also be correct).
  e.g. "*Down came the rain; up went the umbrellas*".
- separate independent clauses joined by conjunctions (such as *accordingly, also, consequently, furthermore, hence, however, moreover, nevertheless, otherwise, still, therefore, thus*)
- separate items in a complex list if you have already used the comma.
  e.g. "*He needed several items: a long, strong piece of string; a toy cart; and a cloth*".
- separate elements of a series that are too long or complex for commas.

The hyphen (-) is used to show that two or more words are to be treated as a single unit.
Many compound words join together using hyphens (e.g. *life-cycle, mother-in-law*), although Americans and Australians tend to drop the hyphen in some words more rapidly that the British (e.g. *seagrass* v. *sea-grass*, *cooperate* v. *co-operate*). Use hyphens when two or more nouns, or an adjective and a noun, are put in front of another noun: e.g. *colour-blind men, red-hot stove, signal-to-noise ratio*). Do not hyphenate prefixes unless you need to do so for pronunciation or sense (e.g. Smith *resigned* from the Broncos, but has now *re-signed*").

The apostrophe (') indicates something that has been left out (e.g. *it's = it is; don't = do not*).
Letters used to be added to the end of the word to show what role the word played in a sentence, but most of these signals have now disappeared. The possessive was originally indicated by adding *–es* to a noun:

e.g. *Johannes house* meant *the house that belongs to John*, i.e. *John's house*).

The *e* in *–es* vanished, but the apostrophe replaced it.

The *apostrophe plus s* (*'s*) indicates ownership or possession. Pronouns have a special form to indicate ownership (*my, your, her, his, its, own, their*), so they do not use the apostrophe. If a noun that 'owns' the idea or object is singular, put *'s* at the end. If it is plural (and therefore already ends in an *s* or *x*), put ' alone (except for irregular plurals, such as *women, men, sheep*, then put *'s*).

Submission

After several drafts and much editing, you now have a manuscript ready for submission to your chosen journal. Presumably you have written the manuscript in the style and format required for that particular journal. Double-check that you have followed the *Instructions to Authors* exactly (many journal provide a check-list for authors). Triple-check your references. Compose a letter to the editor to accompany the manuscript. Address the editor by name and briefly provide your reasons for submitting your manuscript. Remember, almost one quarter of manuscripts are rejected outright because they were not in the scope or context of the journal (this is generally your fault, reflecting your poor choice of journal). Another quarter are often directly rejected by editors after their subjective assessment of poor quality, limited content, incorrect science or bad presentation. The remainding manuscripts make it through to the next stage of the assessment process.

Editors send out suitable manuscripts for peer review (to 2-3 independent referees who usually have established credentials in your field of study). Referees are not paid for the privilege of reading your paper. Humans are psychologically habituated to proffering criticism on written drafts, so they will invariably find something to criticize or correct. When you receive the referees' comments, resist the temptation to hit back – it achieves nothing. Carefully evaluate all comments, remembering that reviewers are proxies for future readers. If they have misunderstood you, the chances are other readers will too. Revise your manuscript accordingly, or provide an explanation to the editor why you have not revised particular items. If matters cannot be resolved, ask if the paper could be sent to another reviewer. As a last recourse, you can withdraw your manuscript from that journal and submit it elsewhere.

Having invested considerable time, effort, energy and angst into preparing a manuscript, it is still immensely gratifying and satisfying when your paper is published in the scientific literature. I still get an immense sense of accomplishment and pride whenever my papers are accepted.

Professor Peter O'Donoghue
Faculty of Science
UQ, 2010