MTMG05 - Writing skills

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Recommended reading:

The Elements of Style, W. Strunk and E. B. White, Macmillan.

Suggested further reading:

Effective Writing, C. Turk and J. Kirkman, E and FN Spon.

Writing Successfully in Science, M. O'Connor, Chapman and Hall.

Effective Communication for Science and Technology, J. van Emden, Palgrave.

Fowler's Modern English Usage, Oxford University Press.

The Complete Plain Words, E. Gowers, Penguin.

The Language Instinct, S. Pinker, Penguin.

There is also some interesting material on M. E. McIntyre's web site: http://www.atm.damtp.cam.ac.uk (look under Lucidity and Science)

The importance of writing skills

Writing skills are important for the *accurate* and *efficient* communication of information, ideas, instructions, etc., from the writer's brain to the reader's brain. Bad writing wastes the reader's time and effort. Worse, it can lead to confusion and misunderstanding.

Scientific writing is an essential part of the process of scientific thinking. Lucid writing helps to clarify ideas, concepts, analogies, images, etc., in the writer's brain as well as in the reader's.

There are numerous rules, recommendations, and guidelines for good writing. Some of these are arbitrary conventions or historical accidents, and simply have to be learned and adhered to. However, many really do make a difference to the clarity of what is written. They make a difference because reading a piece of text involves a highly complex decoding process, carried out by a human brain, in which factors such as the complexity of the message, tiredness of the reader, and distractions and other sources of "noise" can all reduce the fidelity with which the message is decoded; good writing encodes the message in a way that eases the decoding task and helps to reduce the adverse effects of "noise", for example by making use of word and phrase patterns, reducing "verbal camouflage", and presenting information in a logical order.

In the writing skills part of this module we will learn a few rules, recommendations, and guidelines for good scientific writing.

Some grammatical rules (mostly from Strunk and White, see also Fowler)**.**

1. **Form the possessive singular of nouns by adding** *'s*, even when the noun ends in *s*. E.g., *Hoskins's refutation of Thuburn's hypothesis*.

2. **Use commas to separate items in a list**. E.g., *The Atlantic, Pacific, and Indian oceans*; or *where* ρ *is the density of sea water,* g *is the acceleration due to gravity, and* h *is the depth of the mixed layer*. Note some people prefer to omit the comma between the last two items in a list. Either convention is acceptable, provided you are consistent.

3. **Enclose parenthetic expressions within a comma pair**. E.g., *Stratus cloud feedbacks, involving either solar or thermal infrared radiation, are greatly underestimated in the model*. Here the text within the comma pair is parenthetic; it could be omitted and the sentence would still make sense. A comma pair should not be used when a clause is restrictive, i.e. when it limits or defines a noun. E.g., *Billy the kid*; *President John F. Kennedy*; *the value that Smith and Jones (1966) derived theoretically is confirmed by our experiments*. However, a comma pair should be used when a clause is nonrestrictive, i.e. merely adds extra information. E.g., *this value, which Smith and Jones (1966) derived theoretically, is confirmed by our experiments.* Note we must use both members of a comma pair.

4. **Place a comma before a conjunction (a linking work like** *and* **or** *but***) introducing an independent clause**. E.g. *The surface temperature and lapse rate were specified, and the model was run to a steady state*.

5. **Join independent clauses by a semicolon, not a comma**. If two independent clauses are not joined by a conjunction then use a semicolon. E.g., *In the troposphere temperature generally decreases with altitude; in the stratosphere it generally increases with altitude.*

6. **Do not use a full stop in place of a comma to break a sentence**. The following sentence has been incorrectly split into two: *I met him on a plane many years ago. Coming home from a conference on meteorology.*

7. **Use a colon to introduce a list, an amplification, or an illustrative quotation**, but do not separate a verb from its complement or a preposition from its object. E.g., *The experiment was run with three values of* τ*:* 1×10^5s, 2×10^5s, *and* 4×10^5*s*, but not *The experiment was run with:* $\tau = 1\times10^5$s, $\tau = 2\times10^5$s, *and* $\tau = 4\times10^5$s. E.g., *The simulated SST is seriously in error: there is a strong cold bias, and the seasonal cycle is 6 months out of phase with observations*.

8. **Use a dash to set off an abrupt break or interruption, or to announce a long summary**. E.g., *His first thought on getting out of bed—if he had any thought at all—was to get back in again*. Dashes should be used sparingly in scientific writing as they strongly interrupt the flow. A comma pair is usually better. Similarly, it is often better to replace parentheses by a comma pair. When revising a text, ask yourself whether any parentheses can be omitted.

9. **The number of the subject determines the number of the verb**. E.g., *Water vapour in the upper troposphere and lower stratosphere have an important effect on the climate system*. (*has* not *have*). An important and commonly occurring case is the word *data*. Most people who care at all treat the word *data* as the plural of *datum*, from the latin. Thus, *the data were analysed...*, not *the data was analysed...* . However, language evolves. *Data* plural is an anachronism and will almost certainly be superseded eventually by the more natural *data* uncountable, which takes the singular verb, like money, cheese, milk, etc. However, to avoid losing marks to a pedantic examiner, I suggest you stick to *data* plural when it really matters.

10. **A participle phrase at the beginning of a sentence must refer to the grammatical subject.** E.g., *Being in a dilapidated condition, I was able to buy the house very cheaply*. Presumably the writer meant that the house was in a dilapidated condition. The sentence should be rewritten: *I was able to buy the house very cheaply because it was in a dilapidated condition.*

Some grammatical constructions that used to be considered incorrect are actually acceptable and, indeed, are often more natural.

11. **Split infinitive**. E.g., *...to boldly go where no man has gone before*. E.g. *The chef asked me to gently fry chopped onions*.

12. **Preposition at the end of a sentence**. E.g., *All the data they could lay their hands on*. E.g., *People worth talking to*. Many common verbs in English are "phrasal verbs", composed of a verb and a "preposition" that is really an adverbial participle. In these cases the "preposition" cannot be separated from its partner. E.g., *The aeroplane took off*. E.g., *Someone I don't get on with*.

Lucid writing

Psychologists and linguists are just begining to understand the way the brain decodes spoken or written language (see Pinker's superb book *The Language Instinct*). Recognizing and understanding the reader's task of decoding can indicate ways for the writer to write more clearly, that is, in a way facilitates the reader's task. For example, the small amount of information that the brain can keep in short term memory limits the length and complexity of sentences that can easily be understood. The rate at which the brain can absorb new facts and ideas limits the rate at which new facts and ideas can usefully be presented. Minimizing "verbal camouflage" will ease the reader's task.

In reading a piece of prose, a reader's brain has to solve a deeply complex pattern-perception problem. This involves recognizing letters, words, and punctuation marks; it involves recognizing word patterns and syntactic structures; and it involves understanding the meaning of what is written at various levels. According to the **Pattern Perception Hypothesis**, the brain solves this problem in essentially the same way that it solves simpler pattern-perception problems. The pattern perception hypothesis suggests that, by writing in a way that makes patterns at various levels explicit and easily recognizable, rather than disguising and obscuring them, we ease the computational burden on the reader's brain, allowing it to concentrate on the genuinely difficult parts of the task of comprehension.

There is one school of thought that claims that the way one writes is merely an arbitrary matter of style and culture, and that imposing rules and guidelines on the way one writes is a restriction on creativity and the power to express oneself. Thinking about writing as part of the process of communication, with humans brains as the encoding and decoding devices, shows that good writing is not merely an arbitrary matter of style and culture, but has its roots in biology. There is an objective definition of good writing: that which facilitates the process of communication by making the message as easy as possible to decode.

Some recommendations and guidelines for lucid writing (distilled from Fowler, McIntyre, Pinker, Strunk and White, and Turk and Kirkman)

13. **Omit needless words**. Be direct. Superfluous material acts like verbal camouflage, so that the reader's brain has to work harder to extract the intended meaning. Compare (a) *Owing to the fact that HCFCs have been proposed as a substitute for CFCs, the question as to whether they have an adverse environmental impact arises* with (b) *The environmental impact of HCFCs should be assessed, since they are used as CFC substitutes*.

14. **However, do not omit essential details**. This includes essential details of the topic being discussed. It also includes essential parts of the sentence structure: see note 24 below for some examples.

15. **Avoid long, unfamiliar words when short, familiar words can do the job**. E.g. compare *This work has involved the acquisition of skills and techniques required when working with...* and *In this work we have learned new ways of working with...* . Writers might be tempted to use long words for two reasons: to impress, and to confuse. They might think that long words will be taken as a sign of erudition and intellectuality. Worse, they might hope to conceal a lack of genuine ideas behind a smokescreen of long words. However, experience shows that readers (including examiners) are more impressed by the clarity of the argument than by the size of the vocabulary.

16. **Abstractions**. Avoid using high-level abstractions when a more concrete, specific word or idea fits. E.g. *The regressiveness and anomalies caused by the export duty and surcharge...* . What does the writer mean by regressiveness and anomalies?

17. **Choose new technical terms and mathematical symbols carefully.** Well chosen technical terms or mathematical symbols can speed up the communication process by expressing a complex idea in a single word or symbol while being self-explanatory and easily memorable. E.g., *Tropopause* for *the boundary between the troposphere and stratosphere as identified in temperature, potential vorticity, or constituent profiles*. Some bad examples: *virtual effect* (meaning the effect of water vapour on the density of air, as expressed through the virtual temperature); *let* N *be a linear operator and* L *a nonlinear operator*. *Easterly* and *westerly* are established in Meteorology, but do they mean from the east or towards the east? *Eastward* and *westward* are self-explanatory.

18. **Avoid acronyms**. Some authors of scientific papers are tempted to introduce acronyms for almost any phrase that is repeated three or more times in the belief that it will speed things up. (This is particularly true for references—see note 40 below). Although it might speed up the writing process (marginally), in fact it has the opposite effect on the reading process. Unfamiliar acronyms can severely slow down the reader's comprehension of a piece of text. Even familiar acronyms can speed up communication only marginally; and they may not be familiar to all your readers. If you feel you must use an acronym then define it at its first occurrence.

19. **Beware of ambiguities.** E.g., *The summary of information contains totals of the numbers of students broken down by sex, marital status, and age*. E.g., *The pharmacist dispensed with accuracy. E.g. The experiments measured ozone at high levels*. Often the best way to spot ambiguities is to reread the material later with a fresh mind.

    A common source of ambiguity is sentences beginning "*This* ..." without specifiying what "this" is. The ambiguity is easily avoided by lucid repetition of the antecedent. E.g. *This*

theory... or *This heavy rainfall*... .

20. **Lucid repetition**. Use the same word or words to refer to the same thing, and don't be afraid of sounding repetitive. Avoid the opposite of lucid repetition: **gratuitous variation**. (Fowler sarcastically calls it **elegant variation**.) It does not make your writing more interesting; it makes the reader's pattern perception task more difficult, sometimes impossible. Again, it's verbal camouflage. Compare (a) *Whereas the spectral method engenders Gibbs fringes, no discretization oscillations are manifested by the TVD algorithm* with (b) *Whereas the spectral method produces Gibbs fringes, the TVD method produces no Gibbs fringes*. *Former* and *latter* are often examples of gratuitous variation, causing the reader to backtrack to find out what they refer to; repeating a word or phrase instead might ease the readers task.

21. **Lucid pattern repetition**. Lucid repetition can also be used at the level of word patterns to express related ideas in a similar form. E.g., *The model's troposphere has a conspicuous warm bias, and its stratosphere has a conspicuous cool bias.*

22. **Incongruous repetition.** Do not use the same word to mean two different things. E.g., *The field of quantum field theory*. Beware of words that have an everyday meaning and also a specialist technical meaning. E.g., *His normal mode of working was to linearize the equations and find the normal modes*.

23. **Incongruous juxtaposition**. Avoid using words that appear to be related when their intended meaning is not related in the same way. E.g., *The experiments concentrated on dilute solutions*, or *For clarity we make the optically thin approximation*.

24. **Make patterns explicit**. E.g., in an *if... then...* clause explicitly include the *then*, such as *If he arrives before midnight, tired, wet, and hungry, having travelled so far, [then] after his bath give him some supper*. E.g., *There are three reasons why... First,... Second,... Third,...* . E.g. *Sally loves cheesecake more than Harry*. (*...more than Harry does*, or *more than she loves Harry*).

Some sentences can be difficult to understand because the reader has to hold one or more incomplete phases in memory for a long time while waiting for a complementary piece of the phrase. The reader often has to reread the sentence several times to make sense of it. It's not merely the length of the sentence that matters; it's the structure.

25. **Short, crisp, clear sentences are easier to understand than long, tortuous sentences**. Think about breaking long sentences into shorter sentences. Usually each sentence should make no more than one point.

26. **Subject-verb separation**. Keep the verb close to the subject. Anything of length between the subject and verb tends to be read as an interruption to be regarded as less important. E.g., *The smallest of the URF's (URFA6L), a 207-nucleotide reading frame overlapping out of phase the* NH_2 *-terminal portion of the adenosinetriphosphatase (ATPase) subunit 6 gene has been identified as the animal equivalent of the recently discovered yeast* H^+ *-ATPase subunit 8 gene.* One way to fix this example is *The smallest of the URF's is URFA6L, a 207-nucleotide reading frame overlapping out of phase the* NH_2 *-terminal portion of the adenosinetriphosphatase (ATPase) subunit 6 gene; it has been identified as the animal equivalent of the recently discovered yeast* H^+ *-ATPase subunit 8 gene.*

27. **Revolting parenthesis construction.** Avoid constructions like *Cyclones rotate anticlockwise (clockwise) in the northern (southern) hemisphere, where the coriolis parameter is positive (negative)*. Much better is *Cyclones rotate anticlockwise in the northern hemisphere, where the coriolis parameter is positive, and clockwise in the southern hemisphere, where the coriolis*

parameter is negative. The second form is quicker to read and understand, even though it is slightly longer.

28. **Top-heavy sentences**. E.g., *We turned the parameterization of convection with the moisture flux convergence closure developed by McCloud (1988) off*. E.g., *That the mean meridional mass flux in the lowermost stratosphere associated with eddies and synoptic systems should be equatorwards is surprising*. These two examples are easy to fix. *We turned off the parameterization... . It is surprising that the mean meridional circulation... .* By the way, contrary to popular belief, a preposition is not necessarily a bad thing to end a sentence with.

29. **"Onion" sentences**. E.g., *The hypothesis of Smith (1967), which the experiment that Jones (1971) proposed tested, was found to be incorrect*. When the reader reaches the point *Jones (1971)*, indicated by the dashed line in figure 1, there are three unresolved branches in the sentence tree, which the reader has to keep track of.

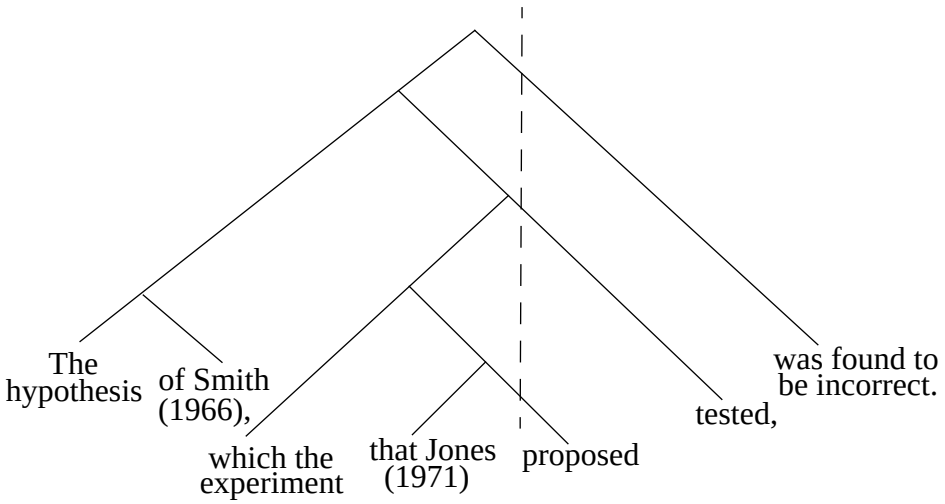

Figure 1. Sentence tree for the onion sentence in note 29.

30. **Garden path sentences.** Many words can play more than one role in sentence structure. Often the role that a word plays can't be determined unambiguously until later in the sentence. Rather than keep track of a fast growing tree of possibilities, it appears that the brain makes an educated guess and carries on scanning the sentence. If that guess later turns out to have been wrong then it is necessary to backtrack and try again. Sentences that mislead the reader like this, causing him or her to backtrack, are called "garden path sentences". E.g., *The man who hunts ducks out on weekends*. E.g., *We have taught courses and research-based courses*.

Scientific writing: papers, dissertations and theses.

Scientific writing, such as producing a paper or dissertation, involves a number of considerations beyond the general recommendations for lucid writing.

31. **Clarity**. In some kinds of writing there are valid reasons to be deliberately ambiguous, obscure, amusing, or wild of tongue, e.g., in poetry, diplomacy, or comedy. The purpose of scientific writing is to inform, rather than to entertain or amuse, so clarity is of paramount importance. Analogies have a place in scientific writing, but rarely metaphors.

32. **Style - formality**. Avoid a breezy or flippant style. It would suggest that the writer is not treating the subject as seriously as it deserves. Also, avoid slang. As well as being informal it might not be familiar to readers whose first language is not English. Don't be rude or condescending to the reader, e.g., *not all first order methods are monotone, as some readers might be inclined to believe*.

33. **Style - personal or impersonal**. There is a strong case for avoiding *I, me, my*, etc., in scientific writing, because science is supposed to be as objective as possible and independent of personal considerations. However, it is not enough simply to replace *I* by *we* etc. In a single author paper or dissertation this leads to the **incongruous royal we**. On the other hand, the **diplomatic we**, meaning "you and I, dear reader", or "all of us including you, dear reader", or even "we the scientific community", can be a valid and useful part of scientific writing. E.g., *Combining equations (7) and (8), we find the result (10)*. E.g., *Our understanding of baroclinic instability has advanced considerably in the last two decades*.

34. **Style - tense**. It is usually, but not always, obvious which tense to use. Use the present tense for things that nature does and for things that are known or accepted, e.g., *Dry air descends in subtropical anticyclones*. Use the past tense for things that occurred or people did, e.g., *We measured the soil temperature every hour for 10 days*. Either the past or present tense might be used to describe the results of an experiment, depending on the context. E.g., *The maximum soil temperature was* $10.2^{\mathrm{o}}\mathrm{C}$, but, *Figure 3 shows the zonal mean zonal wind from the model integration. The maximum westerly wind speed is* $37\mathrm{ms}^{-1}$.

35. **Style - active or passive voice?** One way to avoid using *I, me, my*, etc., is to use the passive voice, e.g., *The data were analysed* instead of *I analysed the data*. However, there is a danger of omitting essential information. E.g. *It is thought that* ... Thought by the author or by the wider community? Moreover, excessive use of the passive voice saps the vigour and directness from writing. The decision whether to use active or passive voice should rest on considering the information to be conveyed and how it relates to sentence structure.

    First note that the active and passive voices are rarely equivalent. In the following example, the passive voice allows the second sentence to begin with the topic of the sentence: *Matsuno's paper is about stratospheric sudden warmings. A stratospheric sudden warming is caused by a sudden amplification of wave activity near the polar vortex*. Rewriting the second sentence in the active voice makes it sound like a non sequitur. *Matsuno's paper is about stratospheric sudden warmings. A sudden amplification of wave activity near the polar vortex causes a stratospheric sudden warming*.

36. **Put in the topic position the old information that links backward; put in the stress position the new information that you want the reader to emphasize**. The last example in note 35 illustrates this general principle. The **topic position** at the start of a sentence should contain who or what the sentence is about, or should contain "old" information that links back to information introduced earlier. New and interesting information to be

emphasized should be introduced in the **stress position**, usually at the end of a sentence. (More specifically, the stress position is the point of syntactic closure, i.e., the point where the reader knows that there is nothing left in the sentence except the material currently being read.) Do not try to introduce more pieces of new information in a sentence than there are stress positions to accomodate it. In the example in note 26, introducing a semicolon created a second stress position, which helped to introduce the new material where the reader expects it.

37. **Equations**. Use standard notation where possible; then there will be fewer new things for the reader to remember.

Proper punctuation should be used even around equations (see, for example, equation (6) below). It is needed just as much as in equation-free writing. As a corollary, a sentence should not start with a mathematical symbol, e.g.,

$$x = 0 \textit{ therefore } P(x) = 0,$$

because the sentence cannot be capitalized. A better choice here might be

$$\textit{Because } x = 0 \textit{ it follows that } P(x) = 0.$$

Choose mathematical symbols carefully for maximum clarity, following established conventions where appropriate. For three quantities of the same kind, choose three symbols of the same kind, e.g., a, b, c, not a, Π', ε_2 (lucid pattern repetition, not gratuitous variation). Make sure all symbols are defined. Be careful to use the same symbol for the same quantity throughout the paper or dissertation, and be careful not to use a symbol twice with different meanings.

Check units and dimensions carefully. SI units should be used. (Some exceptions such as mb are acceptable in Meteorology.)

Short equations or expressions may be placed inline, e.g., $a^2 = 3$. Longer equations, or equations that need to be referred to later, should be displayed on a separate line with an equation number. E.g.,

$$E = mc^2. \tag{6}$$

Most word processing packages will automatically number equations, as well as automatically updating cross-references if equations are renumbered.

38. **Figures and tables**

Figures and tables can be a very efficient way of conveying information. The design and use of figures and tables should be guided by the same principles as the main text: clarity, and efficiency of communication.

Consider the purpose of each figure or table. One intended to illustrate a single idea can be much less complicated than one intended to give detailed information for reference. Don't overcomplicate; present the minimum amount of data needed to make your point.

For figures make sure that curves and axes are clearly distinguishable and that labels are large and clear enough to be to read. Use a good quality reproduction, not an n^{th} generation photocopy.

Figures should be reduced in size as far as possible to save space and to minimize interruption to the text. However, do not reduce them to the point where they become unreadable.

All curves and contours should be clearly labelled. Choose the layout of the labelling to minimize the reader's effort, e.g., by having labels next to the relevant curves rather than in a key at the side of the figure.

Greyscale shading, or even colour, can sometimes help a figure to make its point, but not always. Ask yourself *would a colour version convey the information more clearly?* not *would a colour version be more pleasing to the eye?* Also, note that most journals charge authors extra for colour figures.

Tables can be 'open', with no ruling, 'semi-closed', with just some horizontal and/or vertical ruling, or 'closed', with a complete set of horizontal and vertical rules. Open tables provide no guidance to the eye, whereas the dense network of lines in a closed table can overwhelm the information being presented. Most readers prefer a semi-closed layout in which the ruling is used selectively to highlight significant groupings of data.

Every figure or table should have a caption. The caption should be detailed enough to allow the figure or table to be understood in isolation, without having to read the main text. It is a good idea to use a different font for captions (e.g. slightly smaller or italic), or to indent them, so that they are distinuishable at a glance from the main text. Avoid "lazy figure captions" like *Figure 5. Same as figure 3 but for experiment B*, which make the reader flick back several pages to find out what's in the figure.

Every figure or table should be referred to in the main text.

39. **Abstract**

A dissertation or paper must contain an abstract. For a University of Reading PhD dissertation the abstract should not exceed 300 words. For MSc dissertations the abstract should occupy no more than 1 page.

The abstract is especially important. It is one part of a dissertation that an examiner will pay particularly close attention to (along with the introduction and conclusions). A busy scientist wondering whether a paper is worth reading will decide on the basis of the abstract. An even busier scientist who doesn't even have time to read the whole paper needs to get the main ideas and conclusions as clearly as possible from the abstract alone. Abstracts are especially important now that many are available in electronic format on the world wide web.

An abstract is a summary. It should clearly convey the main points of the dissertation or paper, including (i) background and motivation, (ii) brief description of what has been done, (iii) key results, (iv) conclusions.

Bearing in mind the purpose of an abstract, and the circumstances under which it is likely to be read, suggests that the logical order for an abstract is make the most interesting and important points first, rather than in the order of a logical argument or in the chronological order of discovery.

An abstract should be *informative*, not merely *descriptive*. Don't just say that something was measured; give the result of the measurement. Don't just say that something will be discussed; give the main conclusion of the discussion.

Write the abstract last, when you have the best overview of the contents of the dissertation or paper and you have had the maximum opportunity to organize and clarify your ideas.

40. **References, and plagiarism**

It is very important to state the origin of anyone else's data, results, or ideas that you use by giving a reference. This is so that (a) proper credit is given to the original author, and (b) the reader can go back to the cited paper for more detail. Since most references are to papers in peer reviewed journals, they also give some confidence that the work referred to has been scrutinized and approved as a valuable contribution to the field, though there is no guarantee that it is right, or even widely accepted. Note that the Science Citation Index can help you to find out who has subsequently referred to any given paper.

Failure to give a reference where you should means that implicitly you are claiming that work as your own. This is plagiarism—see below.

On the other hand, when an idea or piece of work is your own make sure you do take the credit; don't leave the reader wondering. E.g., *In this dissertation it is shown that...*

For single and double author papers a reference should consist of the authors' surnames plus the year. When there are three or more authors use the first author's surname plus *et al*. plus the year. The exact format depends on whether the authors names form part of the sentence, e.g., *as discussed by Thuburn and Craig (1997)*, or not, e.g., *the behaviour predicted by the barotropic governor model (James 1987).* If there are several references to the same topic put them within the same pair of parentheses separated by semicolons, e.g., *the hidden-variable picture of wave mechanics (Bohm 1952; de Broglie 1953).* If you need to refer to more than one paper in a given year by the same set of authors then distinguish them by adding a, b, c, etc to the year, e.g. *see Smith (1989a) for a review*.

Don't be tempted to introduce acronyms for references (e.g. *Hoskins et al. (1985), hereafter HMR*). This just makes it harder to read.

Occasionally you might want to refer to unpublished material. Make sure the original author is happy for you to refer to that material. Give the reference as the author's name followed by *personal communication* plus the year. E.g., (*M. Blackburn, personal communication, 1997*).

Full details of any work referred to (except personal communications) should appear in a reference list at the end of the dissertation or paper. (Do not give a separate reference list after each chapter.) This list should be in alphabetical order of the first authors' surnames. The exact format will depend on whether the reference article is a paper, book, thesis, etc.,...

E.g. paper:

Andrews, D. G., and M. E. McIntyre, 1978: An exact theory of nonlinear waves on a Lagrangian-mean flow. *J. Fluid Mech*., **89**, 609-646.

E.g., book:

Bell, J. S., 1987: Speakable and Unspeakable in Quantum Mechanics. Cambridge University Press. 212pp.

E.g. PhD thesis:

Gregory, A. R., 1999: Numerical simulations of winter stratospheric dynamics. *PhD Thesis, University of Reading, UK*.

E.g. world wide web site

Bournemouth University, 1996: Guide to citing internet sources [online]. Poole: Available from: http://www.bournemouth.ac.uk/library2/html/guide_to_citing_internet_sourc.html [Accessed 31 August 2000].

In this last example the name of the organization is given because the author's name was unknown. The date in brackets at the end is the date the site was accessed. See the above web site for more information on referencing electronic sources. Be very cautious about using information from WWW sites; they are not peer reviewed and there is no guarantee that any information found there is correct.

When reproducing figures or tables from someone else's work give a reference in the caption. If you want to reproduce an already published figure and publish it in a paper of your own then you will need written permission from the copyright holder (usually the journal where the figure was originally published).

Plagiarism. Plagiarism means taking someone else's work and passing it off as your own. Plagiarism is unacceptable and is viewed very seriously by examiners and by the scientific community in general. The University of Reading has introduced a new rule for Higher Degree dissertations requiring the author to sign a declaration of original authorship.

It is not acceptable to copy passages from papers or books or the internet. Instead you should assimilate the information and present it in your own words, giving appropriate references to your sources. In scientific writing direct quotations should be avoided unless they achieve something special. If you do use a quotation give a reference in the usual way.

41. **Logical structure**.

The content of a paper or dissertation should have a logical order. This means logical from the point of view of the reader's understanding. This won't necessarily be the chronological order of the material, or the order in which the writer understood the material.

A paper or dissertation should be well structured. The whole work should form a logical argument. A dissertation should have a title page, an abstract, a table of contents, a number of chapters constituting the main body of the dissertation, appendices if any, and a list of references.

The exact order of the main chapters and their headings will vary from case to case. The first chapter should be an Introduction, describing the background to the work and its motivation, stating what is already known and what the outstanding questions or problems are. The final chapter should be a Conclusions chapter, summarizing the conclusions and putting them in context. It should link back to the questions raised in the Introduction. Where appropriate, outstanding questions and the further work needed to address them should be discussed too. The middle chapters should contain the substance of the research: this might be model or instrument development, experiments, analysis of data, etc., and results.

Chapters are usually divided into sections, each dealing with a subtopic. E.g. the 4th section of chaper 2 would be section 2.4. Sections may be further subdivided into subsections if necessary.

It is important that you communicate your most important points clearly and that you make them prominent so that the reader notices them. In particular, state clearly the scientific questions that you are trying to address, and your conclusions.

Don't be tempted to write everything you know, relevant or not. Be selective. Irrelevant material is verbal camouflage.

One question in scientific writing requiring a certain amount of judgement is what level of knowledge to assume for your readers. They won't necessarily be experts in the field, so some background information and explanation of specialist terms needs to be given. On the other hand it is impractical and undesirable to assume no knowledge of the area at all. For a dissertation I suggest you aim for a level that any of your classmates or any lecturer in your department could understand.

Don't just unload a lot of detail; the reader won't be able to absorb it. A complex explanation or argument must be broken down into a number of manageable parts that form a perceivable pattern. Try to present your argument in a hierarchical, "top-down" way. First give an overview to provide the context for the details that follow.

Provide a "roadmap" and "signposts" to guide the reader and show them where the logical argument is leading. As for the abstract, it's better to be informative than descriptive.

> E.g., This dissertation examines the hypothesis that the mesospheric two-day wave results from a local baroclinic instability. The hypothesis is presented in detail in chapter 2. The hypothesis leads to several predictions, in particular that the amplitude, but not the period, of the wave will be sensitive to the frictional drag resulting from small-scale gravity waves. Experiments designed to test these predictions are described in chapter 3. The results of the experiments are consistent with the baroclinic-instability hypothesis.

E.g., The following derivation assumes that the flow is in geostrophic balance. The possible breakdown of geostrophic balance will be discussed in the next section.

A scientific paper or dissertation is not a detective story; don’t keep the conclusion secret until the last page. It will help the reader to know where the argument is leading.

Make the paragraph the unit of composition. Each paragraph should deal with one topic. The opening sentence should suggest the topic or help the transition between different topics.

Use key positions. For maximum impact, use opening and closing paragraphs, and opening and closing sentences of paragraphs, to make important points.

Use linking sentences to highlight the relationship of one section to another. Use linking phrases to highlight the relationship of one idea to another.

42. **How to go about writing**

Assume you have done some work and you have something to say. Now you want to say it as lucidly as you can. Don't just sit down and start writing; use a top-down approach.

Brainstorm. Jot down all the ideas you might want to include and all the points you might want to make, big or small. Aim for quantity not quality at this stage.

Filter the ideas and arrange them in a logical order, and into a hierarchical framework. Use schematics if this helps. Divide the material into chapters. Remember, a logical order means whatever best facilitates the reader's understanding.

For each chapter, organize the ideas and divide the material into sections and subsections. Decide what tables and figures you are going to include.

Write one section at a time. Don't expect to produce a perfect first draft. It's usually easier to leave the Introduction and Conclusions until you have a first draft of the middle chapters. Leave the abstract until last.

Revise! Lucid writing is not easy, even for experienced writers. Good writers revise drafts many times; ten times or more would not be unusual. Taking a break of a few days between drafts allows you to read the material with a fresh mind and helps to see it the way a reader would. I have marked essays where it was obvious that the writers hadn't even reread the material once. Needless to say, their marks were not high.

Make use of the word processor's built-in facilities for numbering sections and equations and for automatically updating cross references. Also, use the word processor's spelling checker, but make sure it's UK English, not US English, unless you're sending a paper to a US journal.

I find it more convenient to spend a little extra effort to produce publication quality figures at the time I'm doing the work, rather than having to recreate and improve the figures at the time I'm writing up.