

# Science Writing for Beginners

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# Introduction

## Why must scientists write?

Reading maketh a full man; conference a ready man; and writing an exact man.

Francis Bacon (1561–1624)

*Of studies*

‘To be able to write clear and simple English is perhaps the most generally useful of all educational skills. Whatever your profession, you will need at some time to write reports, to present technical information or to compile statements and memoranda. The influence that you have in the world will depend very much on your ability to put your thoughts on paper. More immediately, in writing essays and examination papers, you will need to be able to write clearly and intelligibly’<sup>1</sup>.

Now although Maddox was writing about the general principles of *How to Study* these words of his sum up very well why scientists in particular need to be able to write coherently and effectively. Science is primarily a practical occupation, but it is not sufficient to be able to ‘do’ science if one cannot ‘write’ science also<sup>2</sup>. From the simple business of writing reports of particular analyses to the production of theses and text books, during any scientist’s working life there is a constant need to communicate. Yet a century ago Sir James Barrie commented drily that ‘the scientific man is the only person who has anything new to say and who does not know how to say it.’<sup>3</sup> The most carefully and accurately performed laboratory test is worthless if the investigator is unable to communicate the result in a form which others can understand. In the pressures of modern life it is often averred that there is another reason why scientists must write: it is summed up in the maxim ‘publish or perish’. Probably too often, when a scientist applies for a new post or for a research grant, one of the principal criteria used to assess the applicant’s suitability is the number of ‘publications’ listed in his *curriculum vitae*. At one time this was a not unreasonable idea, as the papers he or she had published were a fair index of the scientist’s research activities. Today, however, the tail is wagging the dog and

scientists feel impelled to publish something—anything—in order to keep up with the rat race. This is a pity but it should not let you lose sight of the fact that publications which have got past the process of peer review—assessment by fellow scientists—and been found worthy of publication really are a measure of your research or developmental capabilities.

At a more basic level, before anyone can be called a scientist it is necessary for him or her to obtain a recognized qualification, which in turn necessitates passing examinations—and it does not matter how much knowledge or skill one has acquired if one is unable to demonstrate to the examiner the extent of that learning.

In the more leisurely days prior to the middle of the present century, education was essentially a broadening experience in which everyone was taught 'the arts' and a few then went on to study 'the sciences'. All Oxford and Cambridge medical students took an arts degree before proceeding to their medical studies and every university required a competence in English, a classical language and often enough a second modern language, as part of their general entrance requirements. The overall effect was that while there were few scientists they were nearly all literate: today the pendulum has swung in the opposite direction and now there are many scientists, few of whom have ever been taught to take the use of language seriously, let alone to consider it a skill which they must acquire as part of their professional education.

All of this does not mean that every scientist has to become an expert in the finer points of grammatical synthesis and analysis, able to quote at the drop of a hat the precise definition of a dangling participle or to cite an example of an ablative absolute. To communicate clearly does not require a technical mastery of grammatical niceties so much as a grasp of the mechanics of constructing a concise and coherent report. Put another way: it is not so much what one has to do as what one must avoid doing that is important to the scientist who would write well.

Whenever one writes it is always for the benefit of a reader—who might be a colleague, an examiner, or even a critic—and it is always necessary to remember the needs of that reader. One must write clearly, not obscuring the message with 'waffle' or 'padding' and not leaving one's readers to puzzle out for themselves the sense of what one is saying. Provision of an informative title and effective

headings and sub-headings; presentation of information in a logical order, including all the steps of an argument; clearly illustrated evidence and examples: these are the essentials of scientific writing and they are not difficult requirements to meet.

Anyone who has taken this book into his hands and read this far has taken the first (and most vital) step in acquiring a facility in science writing—they have realized that writing is an art which can, and should, be learned. It is not difficult to develop the necessary skills. Any scientist worth his salt already possesses the essential attributes of being capable of bringing a logical approach to a new problem and the ability to be self-critical: the only other factor needed is recognition of the nature of the problem. So if you are still with me and are sitting comfortably, let us begin.

# Chapter 1

## Writing good English

This is the sort of English up with which I will not put.

Winston Churchill (1874–1965)  
*Marginal note on document*

True ease in writing comes from art, not chance.

Alexander Pope (1688–1744)  
*An essay on criticism*

Before you turn rapidly to some other part of this book let me make it clear that this chapter is not a detailed study of the technicalities of grammar. It is simply a beginner's guide to the basics of what to do and what not to do.

When you write anything intended to be read by someone else—be it a report, an examination paper or even a personal letter—you do so with the intention of being understood. If you write poor English which does not clearly and logically express what you wish to say, which contains poor syntax or wrong spellings, or which is carelessly (usually excessively) punctuated your reader, or examiner, will form a poor opinion of you and will be left with the impression that you are uneducated or badly taught or—what is worse—that you don't understand yourself what you are trying to say. As Winston Churchill observed in an election speech in 1906, 'Men will forgive anything except bad prose'.<sup>1</sup>

The 'rules' of grammar exist not because grammarians have built up a defensive wall of jargon to keep others out, but to ensure that language does its job of conveying thoughts and ideas efficiently. Just as there have to be rules and signposts governing use of the roads by motor traffic in order to prevent chaos, so there are rules and signposts to prevent chaos in communication. Instead of one-way streets we have syntax (the order in which words must appear if the sentence is not to lose its meaning), and instead of 'Slow' and 'Halt' signs we have commas and full stops. If you can learn the



*Highway Code* you can learn the rules of grammar. However, writing—like driving—is a skill which has to be learned: it very rarely comes completely naturally. Don't make the mistake of considering the correct use of English too unimportant to bother with. Language is the outward expression of people's thoughts and to misuse the one is to misunderstand the other.

Stated simply there are five stages in any written composition:

- 1 You have ideas (or facts) which you wish to pass on to others.
- 2 These ideas have to be put into words and phrases and written down.
- 3 The words and phrases must run together into sentences which are grammatically correct.
- 4 The sentences must follow one another in a logical order, separated into units of thinking called paragraphs.
- 5 The final result must have the impact which you intended upon the reader.

### *Choice of words*

Most people tend to find themselves torn in sympathy between Winnie-the-Pooh, who said that he was 'a Bear of Very Little Brain, and long words bother me'<sup>2</sup>, and Humpty Dumpty. "When I use a word", Humpty Dumpty said in rather a scornful tone, "it means just what I choose it to mean—neither more nor less"<sup>3</sup>. The basic rules are to use the words which first come into your mind (always avoiding slang and made-up words not to be found in a dictionary), and to use short and familiar words rather than those which are long and unfamiliar. Never use six words where one will do. 'In view of the fact that' is much better expressed by 'As'; 'in the contemplated eventuality' is more clearly phrased as 'if so'. Similarly, Anglo-Saxon words are generally better than foreign equivalents. It is better to say 'see above' than to use the time-honoured (and time-worn) *vide supra*, and more people will understand 'delusions of greatness' than *folie de grandeur*. This is not to say that one must always strenuously avoid long or foreign words. Some Latin and French words, or abbreviations of them, have become almost English by adoption. Everyone understands *via* even if they have never studied Latin, and there is simply no short way of expressing long scientific words like 'chromatogram', 'electrophoresis' or 'photosynthesis'.

If you must use foreign words be very sure of their meaning and their spelling, and if you are writing for publication underline them to indicate that they should be printed in italics. Don't be tempted to mix foreign and English words in the same phrase. Some of the commoner foreign words you may wish to use are:

<i>a priori</i>	= from cause to effect
<i>ab initio</i>	= from the beginning
<i>ad hoc</i>	= for this particular purpose
<i>de facto</i>	= in fact, actually
<i>de novo</i>	= newly, again
<i>in situ</i>	= in position
<i>in toto</i>	= entirely, completely
<i>inter alia</i>	= amongst other things
per annum	= each year
<i>per diem</i>	= daily
<i>per se</i>	= of itself
rationale	= reasoning

Do watch out for plural forms of foreign words, however. Four examples of commonly misused words are:

<i>Singular</i>	<i>Plural</i>
Criterion	Criteria
Datum	Data (NB, 'the data are ...')
Medium	Media
Phenomenon	Phenomena

Also beware of abbreviations. Some initial letters (like ml for millilitre, or DNA for deoxyribonucleic acid) are so much in everyday use that there is no problem, but unless there is an international convention for a particular abbreviation you may only confuse your reader. 'CPD' may mean either 'citrate-phosphate-dextrose solution' or 'congenital pelvic deformity' depending upon whether your reader is primarily interested in blood transfusion or gynaecology. If he is interested in both he may well become confused. Less obviously, there is a risk in abbreviating words by using only their first part. Long words are frequently compound adjectives and to separate them only confuses the meaning. For example, 'hypodermic' and 'hypoglycaemic' are both compound words each composed of two different adjectives: to say merely 'hypo' is to beg

the question 'hypo-what?' It also gives no clue as to what noun or verb is intended to follow the compound word. Does one mean hypodermic syringe, or injection, or location? Or does one even mean 'hypodermic' at all? Leaving your reader to puzzle out your meaning is neither good use of English nor very helpful to the clear transmission of ideas.

Bringing together my last two points, the abbreviation of Latin expressions is fairly common—indeed it tends to be overdone—and some confusion often arises about just what particular letters mean. You should not really need to use more than those listed below. If you do then you would probably be better saying it in plain English.

cf.	= <i>confer</i>	= compare
<i>et al.</i>	= <i>et alii</i>	= and other people
etc.	= <i>et cetera</i>	= and the rest, and so forth
e.g.	= <i>exempli gratia</i>	= for example
i.e.	= <i>id est</i>	= that is
NB	= <i>nota bene</i>	= note well
per cent	= <i>per centum</i>	= by the hundred
q.v.	= <i>quod vide</i>	= which see

Most people tend to confuse e.g. with i.e. They do not mean the same, as you can see.

One of the commonest problems in writing is avoiding jargon and clichés. These are mostly perfectly good words (and phrases) which have become spoiled by careless and excessive use until they no longer mean very much; and often, indeed, they come to be so commonly misunderstood that any meaning they do retain is quite changed from that to be found in a dictionary. Such words as 'formulate', 'pinpoint' and 'crucial' should normally be avoided. Because such words are used excessively they may be those which you think of first, but beware of the dangers. Used as an adjective 'grass roots' (opinion) may well describe the lowest form of vegetable life you can think of, but that is probably not what you were trying to say.

Another common problem is the modern tendency to make up words rather than use those already in existence. In particular there is a tendency to proliferate verbal nouns (and even noun-verbs: I recently heard someone say 'give it an invert' when she meant

'invert it'), and these often make nonsense when one considers what they really mean. For example, a frequent mistake made by biomedical scientists is with the noun 'aliquot'. An aliquot is one of a number of equal portions into which a volume of fluid may be separated; yet editors and examiners often read descriptions of how (e.g.) a scientist 'aliquoted' a serum in 200  $\mu\text{l}$  amounts. Unless the original volume was exactly divisible by 200 they could not be aliquots; and what is really meant is 'dispensed' which is a perfectly good verb while 'to aliquot' is not—at least, not in British English. Such misuse of words is not only misleading but is ugly and only serves to add to the reputation of scientists as uneducated (even if well trained) and only semi-literate. Or maybe the anonymous diplomat quoted by Sir Ernest Gowers was right when he observed that 'what appears to be sloppy or meaningless use of words may well be a completely correct use of words to express sloppy or meaningless ideas'.<sup>4</sup>

### Construction of sentences

Any word standing on its own has little meaning, even if it may seem obvious at first glance. For example, did you know that the *Oxford English Dictionary* gives 91 meanings for the word 'take'? So the meaning of a word must depend on its context—and this means not only the other words which surround it but also the order in which they appear.

Generally speaking a sentence is a group of words which is complete in itself and should contain only a single assertion, exclamation or comment (e.g. 'The tests should be incubated at 37°C.'; 'These results were unexpected!'); although a sentence may sometimes contain more than one question or command (e.g. 'What is your name and your address?'; 'Add the di-ethyl ether and then agitate the tube.'). Put another way, within such sentences there will be one or more clauses—that is, groups of words each of which could stand on its own. Generally speaking a clause will contain a subject followed by a verb, and often an object and a complement, thus:

Subject (a noun)	Verb	Object (another noun)	Complement (adjective or adverb)
---------------------	------	-----------------------------	--

The physicist labelled the compound correctly

Now if all this seems to be treading deep grammatical waters we can simplify it by saying that there are just three essential rules for sentence construction:

- 1 Every sentence must have at least one noun and one verb.
- 2 The emphasis should be either (a) in the middle of the sentence or (b) be divided equally between the beginning and the end.
- 3 The shorter and less complex the sentence, the clearer will be its sense.

In the last case, however, remember that a series of short consecutive statements makes dull and difficult reading. Interspersing shortish sentences with a reasonable number of longer ones—each consisting of a number of related clauses joined by conjunctions such as ‘and’, ‘because’, ‘or’ and ‘unless’—can make a passage more varied and therefore more readable. However, this can be overdone too. The great pathologist Rudolf Virchow commented in the *Bulletin of the New York Academy of Medicine* in 1928 that “The conjunction “and” commonly serves to indicate that the writer’s mind still functions even when no signs of the phenomenon are noticeable”.<sup>5</sup>

Very lengthy sentences become so convoluted and drawn out that they are often nearly impossible to follow. Try the following example (from a letter written in 1848<sup>6</sup>):

With regard to that (letter) from Dublin I can only say that your correspondent in telling you that I asserted that “pain had no effect on the mother” informed you as incorrectly as your other “*Dublin man*” who reported my opinion on the “religious objections”—on which subject you say you were induced to write your “Answer” by being informed that I was publicly advocating these so called “Religious objections” and that I had denounced you *ex cathedra* as acting in an unchristian way in advocating the abrogation of pain in labour by anaesthesia—and that the only ground you had for thinking that I did so was hearing it “very casually from a Dublin man.” I really feel astonished that you, who must know as well as anyone, how constantly what a lecturer says is misunderstood or misrepresented, could thus admit on mere hearsay evidence a position to which you attached importance to induce you to take the trouble of writing a formal reply to arguments which never were made use of by me—I never advocated or

countenanced either *in public* or *in private* the so called “*Religious objections*” to anaesthesia in labour, but invariably rejected that objection and many and many a time have had trouble of shewing patients the utter untenableness of such an objection—as is perfectly well known to every one here.

If you worked your way through that and still retained the message, congratulations. The probability is that you got as far as the first few lines then skipped the rest: and that is what readers will do with any of your sentences which are inordinately long.

When you do construct longer sentences be careful not to include too many qualifying or modifying words. Such additions as ‘usually’, ‘under certain conditions’, etc. may be necessary but the line between reasonable (and sometimes essential) caution and fussy legalistic hedging about is a fine one, preferably not over-stepped. To say that ‘normally one may expect’ a certain result is acceptable, but one qualifier is enough. By and large, taking one thing with another, other things being equal, in the normal course of events and generally speaking one can easily overdo it.

It is often said that one should prefer the active voice to the passive voice—that is, ‘The nurse labelled the sample’ is preferable to ‘The sample was labelled by the nurse’. In that example the assertion may be true but often in science writing the passive voice may be preferable. In reporting a series of experiments the style of ‘this was done prior to that being examined’ is certainly less tedious (and less egotistical) than saying ‘I did this before I examined that’. In the same way one should generally prefer the third person to the second person when giving details of a methodology. ‘This is done then that is done, followed by the other’ is better (and less irritating) than ‘(1) Do this. (2) Do that. (3) Do the other’. The latter style always reminds me of the song ‘Oh man river’, with its curiously reminder of slave days—‘Lift that bar, tote that bale’.

Finally, there is syntax to consider. This word is one of three (the others are punctuation and spelling) which probably frighten off more potential authors than any others, but syntax is no more than common sense in action. It merely means the way words are arranged to form phrases and sentences. If you stop to think of the logical meaning of a string of words syntax resolves itself. One should, for example, avoid the painful way of performing an experiment. ‘After standing in boiling water for 30 min, examine the

flask.' Or there was the title of a paper published in 1968 which appeared to herald a new way of becoming pregnant: 'Multiple Infections among Newborns resulting from Implantation with *Staphylococcus aureus*'. Think about it. In the first example it is (presumably) the flask which is to be stood in boiling water and not the operator: in the second case the newborns certainly did not 'result' from bacterial implantation, although their infections may have done. We are really back to the order of subject/verb/object/complement which we looked at earlier, but a little logical thinking will recognize such syntactical errors more easily than attempts to apply theoretical rules of grammar.

### *Forming paragraphs*

A paragraph is a passage of writing which brings together a series of connected facts or thoughts and which divides the text into a series of more readily digested sections. The end of a paragraph marks a place in the argument at which the reader can pause and take stock, ensuring that he has grasped the subject-matter thus far before he proceeds. Generally a paragraph will begin with a 'topic sentence' which indicates what the paragraph will contain, although where an argument is in a number of related parts a new paragraph may well pick up where the last one left off, after a pause for reflection.

Because each paragraph is a separate unit capable of standing on its own, and because paragraphs may vary enormously in length, experienced fiction writers use this writing-unit to give 'pace' to their narratives; short paragraphs move the action along while long ones give a more leisurely 'feel' to the writing. The practical corollary of this for the science writer is that if he fails to divide his writing into reasonably sized paragraphs the reader will be left with a slow-moving, increasingly boring text which is (sadly) altogether too typical of much writing by scientists. Printed text without paragraph divisions is about as 'readable' as a telephone directory, yet all editors are familiar with typescripts in which a six-page article is presented as one long paragraph. Whenever a writer pauses for rest or inspiration it is almost certainly time for a new paragraph.

*Punctuation*

This is another absolute turn-off for the embryo author. We all think we can punctuate and we all know that nobody else does it properly. Like prowess as a car driver, an individual's punctuation is something one can rarely criticize to his face. In fact the commonest fault is not wrong punctuation so much as over-punctuation.

Punctuation merely shows which words should be taken together as units: it is a written way of expressing the pauses and intonations which distinguish normal human speech from the pale imitations produced by voice synthesizers. If in doubt one only has to read a piece of writing out loud with short pauses for commas, longer pauses for full stops, and so on. Again, however, the position can be summed up in four simple rules:

- 1 Full stops. Use frequently
- 2 Commas. Use very sparingly
- 3 Quotation marks. Use only for quotations
- 4 Everything else. Use your common sense, or avoid altogether

Full stops mark the end of sentences and, as already pointed out, the best sentences tend to be short. Commas, on the other hand, represent a lesser pause and serve to emphasize the sub-divisions of thought within a sentence. The general rule with commas is the fewer the better. If in doubt, leave them out.

Quotation marks tend to be over-used also. One should normally place single quotation marks around any passage which is quoted directly from another source and double quotation marks around any quotation from a third source which appears within the single quotation marks. Easy, isn't it?

Other forms of punctuation are generally self-evident. Colons and semi-colons are merely pauses intermediate between a comma and a full stop. Question marks come at the end of a question and exclamation marks only after an exclamation, with brackets and dashes used as an alternative to commas to mark a parenthesis—a passage inserted into the text which is capable of standing on its own—or additional information (such as comparative data) which supplements the main text. Got it? Good!



## Spelling

Spelling is the third of the main worries for wary writers: and this time with good reason. Almost everyone has blind spots with spelling and there are certain words in English which positively invite confusion. Yet accurate spelling is important—especially in science—for three main reasons.

1. Incorrectly spelled words spotted by a reader distract his attention and break the train of what may well be a complex thought process.

2. There is a real risk of ambiguity. While many mis-spellings are self-evident, others are not. As an example of this the chemical L-cysteine is readily soluble while L-cystine is not. In this case an e makes the difference between success in making up a reagent and total failure.

Now, hands up all those who noticed the deliberate spelling mistake in that last paragraph. The one that did not affect the meaning but which would (if undetected) illustrate the third reason why spelling is important.\*

3. Poor spelling is evidence either of semi-literacy and poor education (i.e. the writer doesn't know any better) or of carelessness in one's writing (i.e. he/she can't be bothered to make a proper job of writing a report). In the latter case can one really trust the accuracy of the laboratory work being reported by such an individual? For example, what would you make of the examination candidate who said of a chemical that he would grind it 'with a pedestal and motor'? What he meant, of course, was 'with a pestle in a mortar': but was he being ignorant or just careless? In either case this was scarcely designed to impress the examiner (myself) who marked his paper.

In practice only some 100 words are said to account for a third of all spelling difficulties in English. A number of these fall into one of four categories and knowing the rules for them will save a lot of trouble.

1. The mnemonic many of us older ones learned at school (in the days when the 'English' taught was mainly language and only

\*The correct spelling of the seventh word in the last sentence of the previous paragraph is, of course, 'difference'.