Writing is an integral part of doing research

Writing is not something that you do after your research is completed. Research involves interpretations that follow from and are supported by observations. Often you cannot formulate your interpretations clearly until you write them down; only then might you discover the need for an additional experiment, or even to re-phrase the question you originally formulated. 'Write to find out what you think' may sound strange at first but is absolutely true.

Writing and thinking clearly

Geoscience phenomena and concepts are complex and multi-factored; it can be difficult to think about them clearly. Putting your thoughts and reasoning into writing, and then reading over them as a critical reviewer, can help you to clarify your own understanding. And then you can more effectively communicate your thoughts to others as well.

In fact there are a few simple and enormously helpful 'rules' for effective science writing. One of the best guides I have found is an article by Gopen & Swan; copies are available in the 145 box in GC028, and I have tried to distil the important points on this handout.

from Gopen & Swan, The Science of Scientific Writing (Am Sci, 1990, 78:550-558)

> Science is often hard to read. Most people assume that it is difficulties born out of necessity, out of the extreme complexity of scientific concepts, data and analysis. We argue here that complexity of thought need not lead to impenetrability of expression; a number of rhetorical principles can produce clarity in communication without oversimplifying the scientific issues. The results are substantive, not merely cosmetic: improving the quality of writing actually improves the quality of thought.
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> The fundamental purpose of scientific discourse is not the mere presentation of information and thought, but rather its actual communication. It does not matter how pleased an author might be to have converted all the right data into sentences and paragraphs; it matters only whether a large majority of the reading audience accurately perceives what the author had in mind. Therefore in order to understand how best to improve scientific writing, we need to understand how readers go about reading.

How to write (and think) clearly

There are several qualities to strive for in order to engage as well as inform your reader.

Logic: In science we progress from cause to effect, from the unknown (the question) to the known (the answer). Your reader expects the organization of your writing to reflect this logic, and assumptions, observations and inferences should be presented in the appropriate order. There should be no 'mystery' in science writing.

Conciseness: People are more likely to read and understand your writing if you make it concise (but not turgid). Extraneous material should be excluded, and needless repetition can be avoided by careful organization.

How to get started writing

in learning how to write your goal should not be to write an excellent paper on your first draft. Few if any writers can do that. Instead your goal should be to learn some basic principles of effective writing, so that you can effectively critique and revise your own drafts.

Different people use different approaches to get started writing. Some try talking through their points; others begin with an outline or a series of figures or images. I just write out a first draft, although it is muddled and incomplete. It usually takes several drafts before I reach clarity in my thinking and thus my writing. Revisions are the key, and that means learning to be an objective reader/critiquer of your own writing.

Revising with the reader in mind

Gopen & Swan have excellent guidelines for audience awareness (what they term 'reader–centered writing'). If writers want to communicate clearly they must write in such a way that the reader comes away with the meaning that they intended. How can we construct our writing to have those effects? By using stylistic features of word choice, sentence structure and paragraph organization.

Individual sentences have reader–centered rules of ordering.

(1) Each sentence should make a single main point, and because readers emphasize what comes at the end of a sentence, your main point (like a 'conclusion') should be in that expected emphasis (or 'stress') position, not buried in the middle of the sentence.

Sometimes there may be a secondary point in a sentence, utilizing a subsidiary stress position, for example in a sentence with a semi–colon. There is no rule for the length of a sentence; the only rule is that there are not more viable candidates for stress positions than there are positions available. Location in the sentence is the clue as to what is important.

(2) The subject of the sentence tells the reader what the 'story' is about. This 'topic position' is used to establish the logical flow, to give the reader perspective and context. It prepares the reader for upcoming material by connecting back to what has come before.

(3) The verb should closely follow the subject, and should clearly tell the story or the action. Avoid passive verbs.

Within a single paragraph the main theme or idea should be introduced and clearly stated in the lead sentence. The following sentences should develop that idea and present evidence or examples; it is not necessary (or common) for the last sentence to provide a summary or conclusion. A new idea requires a new paragraph.

The overall organization of a research paper should include separate sections for Introduction (statement of the question and relevant background material), Methods, Results (data, observations, calculations), and Discussion (including interpretation as well as implications and applications). Readers will get confused if they find new methods being mentioned in the results, or if the interpretation and results are mixed together. Throughout the paper, there should be a strong logical flow and continuity between paragraphs.

Additional points and suggestions:

(1) Terms: In science we must use specific terms to convey particular meanings, and it is crucial to keep using the same (appropriate) word as you develop your discussion of a process. Using the same word a number of times ('lexical chains') is helpful for guiding the reader and establishing logical flow in your writing.

(2) Make the best use of English words. If you use comparative terms, be exact and complete. For example is your meaning 'bigger' or 'denser'? Rather than saying 'a change in', specify 'a positive change'; rather than saying 'different than', specify 'deeper than'.

(3) Make regular and correct use of directive linking words (eg 'since', 'because', 'therefore'); they are important for showing readers how different elements relate to one another.

(4) Focus on simplifying and being direct. Remove redundancies, avoid flowery sentences, take out anything that does not move the main argument forward.

(5) Only write what you understand. Put everything in your own words; do not lift phrasing.

Final words

Practise!!! Practise recognizing these elements of good writing in published articles you read or even in textbooks. (And remember that just because a scientific paper is published does NOT necessarily mean it is well written.)