PART I

Basics

1

Writing a scientific article and getting it published

A piece of scientific work is not complete until the results have been written up and published. Planning and doing the work is often exciting; writing about it may seem less so but is just as necessary, and delivers its own satisfaction when you see the work in print.

Why bother to acquire skill in describing your work? First, as you *have* to produce reports then better to do it well than badly. Second, the number of scientific articles published in a year has been doubling roughly every decade or two, but the time that any one scientist can spend reading does not increase. If you write badly those who ought to know your work may not be willing to make the effort needed to understand it, and those who do try will suspect that someone who writes so badly may have been just as confused and incompetent in doing the work as they are in trying to report it.

Most scientific articles exist between the ephemeral and the eternal. If you write concisely and clearly, your readers may begin to look forward to reading about your work, your reputation will rise, and the useful lifetime of your article will lengthen. Good writing cannot convert bad science into good – you cannot make a silk purse out of a sow's ear – but you can ensure that your work is read.

If you are lucky you will have had an opportunity to talk about your work (Chapter 2) before needing to write about it: 'lucky' because talking concentrates the mind and forces you to express things you know that you know but have not (yet) put into words. If an opportunity has not presented itself then make one. A small audience or even an individual is all that you need.

Assume now that you have done original work whose results will, you judge, be of interest to, and perhaps excite, fellow scientists in your field worldwide. How should you go about constructing the article ('article' also known as a 'report' or 'paper', perhaps preceded by 'research')?

The standard scientific article

A few reports of scientific work may be accurately historical: 'We did this and then we did that, which we later discovered was a dead end so we abandoned it and tried something else instead . . .' This approach can be fascinating if a major discovery lies at the end. James Watson's (1968) controversial *The Double Helix* recollecting his contemporary view of the search for the structure of DNA is of this kind. In particular, Watson's account of Rosalind Franklin's part in the DNA work is widely thought to be unfair to her (though it was an accurate reconstruction of Watson's perception at the time). Rosalind Franklin died of ovarian cancer in 1958 at the age of thirty-seven. A corrective account of her life is in the biography of her (Maddox 2002).

But most scientific work, though it may be essential, is mundane and most scientists are unwilling – probably unable – to spend the time needed to follow in the work of others the twists, turns, unproductive directions, and illogical order that characterise much of the daily experience of scientists. Compare Watson's (1968) informal account with the formal publication of the proposed structure of DNA (Watson & Crick 1953).

The standard structure of a report of scientific work has evolved over 350 years or so with a single main purpose:

> ***to convey information to its readers as clearly and simply as possible.***

Such a report will be historically accurate only rarely, when the work went in a straight (unbending) and strait (narrow) line from idea to publication. "Scientific papers in the form in which they are communicated to learned journals are notorious for misrepresenting the process of thought that led to whatever discoveries they describe" (Medawar 1963, 1969). Working scientists are familiar with, and mostly untroubled by, the fact that the report is a sanitised version of events.

There is no single 'correct' structure for a standard scientific report about original research, but there is a usual one – "a ritual liturgy" (Jacks 1961) – that scientists are familiar with and which they understand easily. After the Title, the main headings are: Summary or Abstract, Introduction, Methods, Results, and Discussion ('TSIMRD'). In the medical field most reports of randomised controlled trials follow the CONSORT (CONsolidated Standards Of Reporting Trials) format. Similar standardised structures for specific sorts of medical study are QUORUM, MOOSE, and STARD. Medical reports are generally more ritualistic than others (Peat *et al.* 2002) and are becoming even more so. An unusual example of the double-blind trial format is described (Smith & Pell 2003) when applied to the efficacy of parachutes.

The next few sections take you through the processes of writing such a standard scientific report. 'Listeners tacitly expect speakers to be informative, truthful, relevant, clear, unambiguous, brief, and orderly' (Pinker 1994) and readers will have the same hopes of your writing.

Begin by choosing

- your target journal ▾, and
- someone to represent your readers.

▾ A journal is one kind of periodical that librarians may formally call a 'serial'. In this book, unqualified 'journal' indicates a scientific publication recording accounts of primary research.

Look in your target journal for the specific requirements, arrangement of sections and formatting instructions, then follow these. Different journals have widely differing requirements (and the clarity of their instructions also differs widely). Following a specific format saves a lot of error-prone messing about later, and creates a good impression when the article reaches the editor of the journal.

Write for your chosen person. Someone in a related scientific field is usually a good choice, but if you are about to write a more general account then you would need to choose your target publication and representative of your readers differently, and to use a different structure for your writing. A newspaper article, for example, often begins with a specific instance – a human story – and uses that to develop a generalisation. That technique is unusual in a scientific article, though it may occasionally be effective in attracting attention. Whoever the person you have chosen to write for, make sure they are critical. If their first language is not English then so much the better, for science is international and many of your readers will have difficulties with English (though scientific English is a simplified version of the full language). You may then assume that your chosen reader is scientifically literate, but you will know that they are unfamiliar with rarely used words and with low-level technical details, so you will have to explain clearly and simply what you have done and why you did it.

Complete as many of the data analyses, tables, and figures as you can before beginning to write. If the work you are going to report was other than simple and straightforward you will probably find during writing that you need more analyses and resulting tables and figures.

Some busy bioscientists manage to write good first drafts on railway trains and at airports or on planes. But to begin with you will probably do better to isolate yourself from distractions. When you are ready to start writing, then hide where you cannot be interrupted. Silence telephones, lock the door if you can, and respond only to fire alarms. It is difficult to concentrate on writing

for more than a few hours at a time, so expect to make several such 'retreats' before you have a complete first draft. But once you have begun the whole process keep it going. It is easy to be diverted into other activities and thus to lose momentum.

Table 1.1 lists the sections of a standard scientific report. These are generic headings that allow a reader to recognise what sort of material will follow. But it is usually good practice to make subheadings to identify specific topics within each section. Each of the four largest sections answers a question. This structure has evolved over three and a half centuries and is what scientists everywhere will be expecting. If you deviate from it without good reason you will make your readers' task more difficult than it need be.

It is possible that your work does not fit the standard patterns that journals recognise. If you suspect this then seek advice from an experienced colleague. Remember: you are writing for self-selected readers, and they will be able to understand you most easily if you follow a pattern they are expecting.

Now consider these sections in turn.

Title

Stephen Hales' 1727 masterpiece of plant physiology was titled: *VEGETABLE STATICKS, Or, An Account of some Statical Experiments on the SAP in VEGETABLES : Being an ESSAY towards a Natural History of Vegetation. Also a SPECIMEN of An Attempt to Analyse the Air, By a great Variety of CHYMIO-STATICAL EXPERIMENTS; Which were read at several Meetings before the ROYAL SOCIETY.* The title as originally printed uses eight different fonts, which I have not reproduced here.

Nowadays titles are much shorter. Just as a précis reduces a chapter to a paragraph, or a paragraph to a single sentence, so a title seeks to summarise the Summary in a single phrase or short sentence.

Make the title as short, striking and interesting as possible. More than 20 words is probably too long. You are competing for attention. You need to try to entice readers, as they scan the results

TABLE 1.1 The sections of a standard scientific article and the questions they answer

SECTION	READERS' QUESTION
PRELIMINARIES	
TITLE	What is the work about?
SUMMARY (or ABSTRACT) and keywords	What might interest me?
(SYMBOLS, ABBREVIATIONS)	
MAIN SUBSTANCE	
INTRODUCTION	**WHY** did you do the work?
METHODS[a] (MATERIALS / STUDY AREA)	**HOW** did you do the work?
RESULTS	**WHAT** did you find?
DISCUSSION	**SO WHAT** are the implications?
(CONCLUSIONS)	Remind me what you conclude
SUPPORTING MATERIALS	
ACKNOWLEDG(E)MENTS[b]	Who helped you?
REFERENCES (or LITERATURE CITED)	Where can I find work that you cite in support?
(APPENDICES[c])	Your evidence?
TABLES, with Captions (Legends)	
CAPTIONS (LEGENDS) FOR FIGURES (and PLATES[d])	
FIGURES (and PLATES[d])	
SUPPLEMENTARY MATERIAL (on a website)[e]	
Text, Tables, Figures, Videos	

[a] Some journals put METHODS after the DISCUSSION or even as part of the REFERENCES.
[b] There are two spellings, but a particular Journal will probably impose one. Some journals include ACKNOWLEDGEMENTS in or near the SUMMARY
[c] Some journals put APPENDICES before REFERENCES
[d] PLATES were most commonly photographic illustrations, but the 'Plate' designation is rarely used nowadays
[e] Many journals now allow you, if you wish, to submit extra materials that will be displayed on a website only. Here you may put, for example, a video that can show apparatus, or a dynamic event that cannot be clearly presented at all in the conventional way on paper.

of an electronic search or a journal contents, to nibble at your bait. In that light a title with an intriguing metaphor or allusion may work well. 'Climate change: the Devil's trap?' Usually however the title is more prosaic.

The title should, if possible, be understandable by any scientist. Most of the words in the title should be keywords – words that are used for searching. Start with a keyword, not with 'The' or 'An' or similar padding. Be as specific as you can, consistent with brevity. If the article is about a single species well known to your target readers then give the name: 'Regeneration of laurel forest in Greece' is likely to be more useful to a potential reader than 'Laurel forest in Europe'. If you have compared *Laminaria* and several other large brown seaweeds then move up a rung and put 'large brown seaweeds' in the title. Put the main topic first: 'Taxonomy of *Laminaria* in ...' will be noticed by different readers from 'Climate change effects on *Laminaria* ...'.

Give the strain number of microorganisms, if there is one, because different strains often behave differently. Leave out the authority for plant and animal names (you can put the authority in the main text) because such details clutter the title unnecessarily.

Avoid all except the commonest abbreviations: DNA is acceptable, AAFS (atomic absorption flame spectrophotometry) is not, except perhaps in an analytical chemistry journal. Spell out simple chemical names: 'methane', not 'CH_4'.

There are various types of title. The commonest is a descriptive phrase (without a verb) defining the field:

> 'Radar surveys of the Moon's surface and the "blue cheese" hypothesis.'

Another form is a full sentence posing a question:

> 'Why does the Moon behave like an ellipsoidal blue cheese?'

A third form is a bold declarative statement making a claim:

> 'Radar surveys show the Moon behaves as an ellipsoidal blue cheese.'

Declarative titles do identify what the author thinks will interest readers, but although some journals tolerate or encourage such titles ('Radar surveys *show* . . .'), others consider them bad because they seem to be trying to force a verdict on the jury before the trial has begun.

As you go further with the writing you may get new inspiration and can improve the title.

You can suggest, or may be told, to supply a 'running head' or 'short title' of fewer than 50 or so characters ('space' counts as a character) to appear at the top of alternate pages in the printed article. This may be a convenient place to put the English name ('brown seaweed') of an organism you named in the title in Latin.

Summary or abstract or (rarely) synopsis, and keywords

Make the Summary as short and clear as possible. Many journals restrict you to no more than 2% to 5% of the total length of the text or to 250 words or so. Every word must pull its weight. It may help to have up to half a dozen numbered sections in the Summary. Some journals specify the headings you must use in the Summary; others leave it to you to decide the format. Many of these prescriptions are fairly recent and reflect editors' recognition of the importance of the Summary; their variety shows the difficulty of deciding what a Summary should contain. For example, at least one journal asks for 'highlights' as well as the Summary.

What is the difference between a Summary and an Abstract? The *Shorter Oxford English Dictionary* gives no help: it defines 'abstract' as 'an abridgement or summary'. If there is a difference it may be that one is a précis, giving equal weight to all parts of the article, while the other is selective, concentrating on

- the purpose of the work (but only if not obvious),
- how you did it (but only if not obvious),
- what you found, and
- what you infer or conclude.