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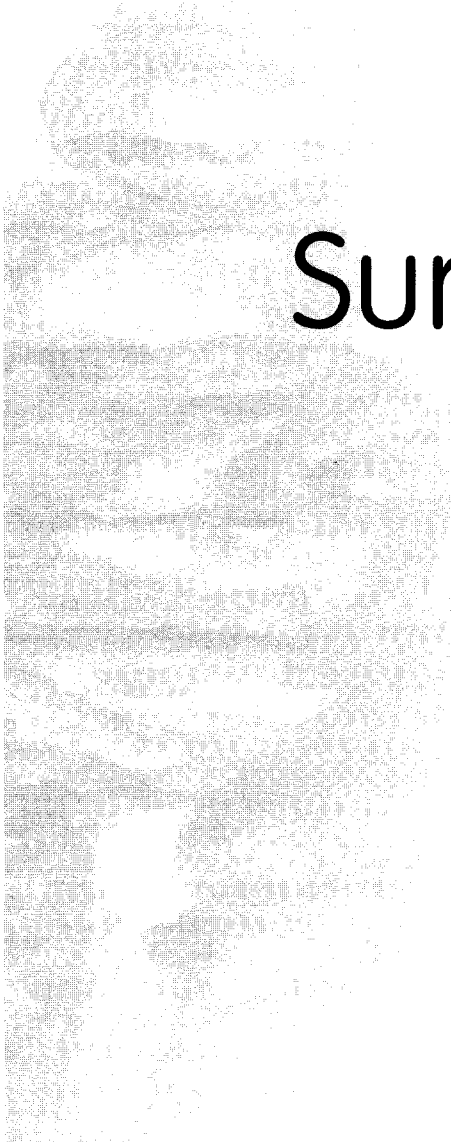

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Chapter 5

Communicating Your Science

Sections of this Chapter

As we have said earlier, while the research itself is up to you, in the world of peer-reviewed research, research hardly exists until it appears in the "literature," by which is here always taken to mean the *peer-reviewed* literature.

To get to this desired state, the report of the work must first pass through the "gatekeepers," these being the editor(s), and then the referees. In effect the report of the work must sell the gatekeepers on its quality and originality and on the clarity of the report itself. As we have said before in connection with grant applications and the like, your chance of success will be better (not to mention the quality of the communication) if you take care to appeal to two classes of people. One class is made up of people who have a superficial knowledge of the field (the editor and the browsing reader) who must, so to speak be wooed. The other people are the experts (the referees, the authorities in the field and your critics), who know the field but must be convinced that your work is worthy by the standards of the field. Similar concepts apply to the doctoral thesis, except that in that case the public also consists of the examiners who must be convinced and of the people who need the

detailed information in the thesis but which may not be in the publications which should flow from it.

Before and after this archival peer-reviewed output there lie the more ephemeral (but nonetheless extremely important) communications delivered directly to the public in the form of oral presentations, invited talks, seminars and conference posters.

In a much more restricted format, but no less important are the *curriculum vitae*, the traditional way to communicate your worth and provide the links to your work for such vital aspects as employment, fellowships, scholarships, prizes and the like.

These are all ways which you should master to communicate your science to the various publics, and these are the topics of this chapter .

(Although we had planned to discuss here the details of how to write applications for Scholarships, Fellowships and Funding in general, on looking at what was already written for these cases, we found that what we wanted to say was previously handled in the Chapter on getting your research funded. Instead of paraphrasing that information here, we ask you to refer to that material in Sec. 4.6.)

5.1 Scientific writing: Generalities

Being a good writer is important. As a scientist, you want to be a good communicator, and to divulge your ideas widely. A good scientist is expected to communicate results and conclusions effectively, both in writing and by direct presentations, both to an audience of scientist specialists from different fields and to the general public.[a] This ability distinguishes (at least partly) very good and good scientists from the average or below.

Beyond this somewhat platitudinous view of the public communicator, there is the fact that, as indicated in previous chapters, the scientist who wishes to succeed in science must be able to communicate

[a]There is no need, however to go to the lengths depicted by the Sidney Harris cartoon, in which the text begins, 'CHAPTER 7. THE STRUCTURE OF THE NUCLEUS. "What?" exclaimed Roger, as Karen rolled over on the bed and rested her warm body against his. "I know that some nuclei are spherical and some are ellipsoidal, but where did you find out that some fluctuate in between?"...'

at many levels in science, to peers (and through anonymous peer reviewers) to peer-reviewed publications, to funding agencies and to various committees (again through peers) for funding and academic recognition. Most of this communication is written, at arms' length, so to speak, when you are not present, and effective written communication becomes essential to success.

This is not the place to learn the basics of prose writing in science.[5] (There are many books for that!) The only thing that must be kept in mind is the central goal is clarity; there should be no doubt as to the meaning of any sentence. Rather, this is the place to discuss how to package and color the messages you want to send, to realize that you will always be sending more than one message at a time, and to understand and control all the messages that you are sending.

Your most important underlying message, one which you cannot avoid sending, is the one of who you are, or at least how you appear. Since you cannot avoid broadcasting some message of who you are, you must learn to broadcast the message that you choose and not a worse one by default. In the musical My Fair Lady, the linguist Henry Higgins proclaims that "The moment one Englishman opens his mouth, he makes another Englishman despise him."[b]

The Canadian media guru Marshal McLuhan has also proclaimed that "the medium is the message." It is equally true that often the "the medium is the messenger too" or, perhaps, "the message is the messenger." Anything of any length that you write shows something of who you are. However, like an actor in a play, if you pay attention to how you write, you can learn to appear to be something better, and even become so by practicing hard at the appearance. Be aware that your voice will be in your prose and try to step back from the work and see what kind of a person you would seem to be.[c]

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[b]The origin of this is actually Shaw himself in the preface to his play "Pygmalion" (the source for "My Fair Lady"), "It is impossible for an Englishman to open his mouth without making some other Englishman hate or despise him."

[c]Richard Rhodes (author of, among other things the Pulitzer Prize-winning "The Making of the Atomic Bomb") in his fascinating little book "How to Write" (William Morrow, New York (1995)) has a very perceptive chapter on "Voices." Among other gems he quotes Ralph Waldo Emerson, "A man cannot utter two or three sentences without disclosing to intelligent ears precisely where he stands in life and thought ..."

Another aspect that you can learn to keep in mind is that usually you are engaged in advocacy — you are putting forth a point of view and trying to get the reader to agree. The more the readers value the person you seem to be, the more likely you are to convince them.

Structuring a text can be done much more effectively if you imagine a rather skeptical reader and answer questions which such a reader might well come up with.[d] It is even better if, in the text, these questions can be answered before the reader thinks of them. If you are successful the reader will begin to think that "You know, this author is really quite intelligent and someone to get to know." This is natural, because this feeling implies that "This author thinks as I do and is thus worth listening to."

As we repeat through this book, you should try to impress two levels of readers.

One is the eagle-eyed professional, perfectly at home in the discipline, an expert Doubting Thomas. It is invaluable if you can persuade a colleague to perform this function — that of the Devil's advocate — by an almost hostile reading before documents are sent out.

You should also, however, try to communicate through the text with someone like an informed layman, perhaps another scientist not at all in your specialty, perhaps even further away. Here again, for really important documents it is worthwhile testing the text on a colleague who is not too close to your work. (Some of the top-ranked journals include this sort of intelligibility for the non-specialist in their criteria for acceptance. They know well that good scientists like to graze a bit outside their specialty and this wider circle of readers will increase the journal's impact.)

As we have stated before, in connection with grant applications and the like, in any committee of your peers this targeting of two levels of reader is often vital. There should of course be an expert or two in your domain, but there will usually be many more who could easily understand the work if it (or at least the principal points) is simply and

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[d]The classic example of this is Steven Weinberg's 1977 popularization of cosmology *The First Three Minutes* (Basic Books), where he says that the book is aimed at a skeptical and shrewd lawyer, one who knows no mathematics but is able to follow an argument closely.

clearly explained. Most members of such committees like to believe that they are not narrow specialists and can get the gist of most things that come before the committee. If you can clearly explain the essentials such people will be much more inclined to accept that you know what you are talking about in the difficult and abstruse sections that they do not really follow. They will feel that much better because they are finding themselves able to follow something noticeably outside their area of expertise, and their opinion of your work will likely be improved considerably. These people also vote on decisions and can sometimes counteract the excessively hostile expert. You may even find that the expert will approve of the way that you can summarize the core of your work and infer that you are thinking clearly and are thus less likely to go astray.

It is true that, in aiming at two publics in the same document, the result may be a bit uneven, stylistically speaking, with dense and complicated paragraphs made up of long and complicated sentences (often so because of length limitations) and much technical verbiage being interspersed with shorter paragraphs, with short, clear sentences with little technical jargon. If this is the price of clarity and of being able to address a wider public, then so be it. Clarity and breadth of impact are worth the price.

(If you are sufficiently successful in science you may be called upon to produce a popularization for the general public. At this point the only respect to be paid to the expert is to avoid saying anything actually technically incorrect, to which one can point and say, "That is clearly wrong." What you strive for in the popular presentation is (as always) clarity. Decide exactly what and how much to say. Better less and clear than more and overdense. If a technical word must be used, define it. This is all that we will say on popularization.)

The order with which writing topics will be treated in the rest of this section is the order in which the young scientist might be expected to have to come to grips with them. This order is (as given above) *Peer Reviewed Publication* (5.2), *Theses* (5.3), and *Curriculum Vitae* (5.4) (Recall that the other important components for which writing skills are required, namely, scholarship and fellowship applications and research proposals, have been dealt with in Chapter 4.)

Books (apart from chapters contributed to edited compilations) are such a large topic and one which does not usually come up early in a scientist career that we have decided not to discuss it here. (Perhaps we might do it in a second edition, if there is one.) Again we cite without graphics the Sidney Harris[1] cartoon showing Professor Hamlin on the telephone exclaiming incredulously, "You mean *Casey's* book on Hamlin's Syndrome will be out before *my* book on Hamlin's Syndrome?"

The communication topics which are not just a written text are *Oral presentation and organization* (5.5) and *Poster organization and presentation* (5.6), which are treated for convenience in the last two sections. (Of course we are aware that placing these last two sections (on communication by something other than text alone) in a logically distinct place, is not the order in which they are required, since the beginning researcher may well have to use these oral skills long before being faced with writing something significant for publication.)

5.2 Peer-reviewed publication

As indicated earlier, next to obtaining the results which are the object of your work, publishing good papers in scientific journals is probably the most important single task you should be performing to advance in your career (this of course presumes that your results are well worth publishing). Trying to build a career without these fundamental building blocks is next to impossible.

We will now turn to discussing some particular aspects of peer-reviewed publication. As we do so, it is worth emphasizing the fact that, the more senior you become, the longer the time you will spend writing. As your career progresses, you will spend less and less time in the laboratory, with more and more time directing those who do and advocating for the work thus done (not only in peer-reviewed papers but also on many other levels). The effort in improving your writing skills for peer publication will be invaluable in these other areas as well, and we will be turning to these areas after we have dealt with peer-reviewed publication.

By what is now a pretty well unshakeable tradition and by the relentless pressure to save space in scientific journals, the scientific publication is about the scientific results and not at all about the details as to how they were obtained. Early scientists like Johannes Kepler or William Harvey would often describe in detail their voyage of discovery (which indeed could help in convincing the reader). By the time of the mathematician Carl Gauss (who wrote originally in Latin), the tendency to conceal (to an almost perverse degree) how the ideas arose became dominant.[e] Like Lieutenant Joe Friday on the old show "Dragnet" on US television, all that is to be communicated are "the facts, ma'am, just the facts." As Richard Feynman observed on his Nobel Physics Prize address (1966) "We have a habit in writing articles published in scientific journals to make the work as finished as possible, to cover up all the tracks, to not worry about the blind alleys or describe how you had the wrong idea first, and so on. So there isn't any place to publish, in a dignified manner, what you actually did in order to get to do the work."

Science is to be communicated in a fashion which resembles the way that mathematicians communicate their mathematics in print, and not at all how they communicate with each other in the conversation in the corridor. You only get to tell the full story if you get a major prize and thus obtain a license to expand and put flesh on the bare bones of the refereed publication. Perhaps in the future with the huge resources of the Web we may be allowed the space to fill in these details in a non-refereed appendix to which the reader could gain access which would not be part of the refereed "just the facts, ma'am" literature, but that time is not yet.

As we have said before, we do not wish to overlap with the usual texts[6,7] on how to write science papers and the like, but we cannot resist the temptation to point the reader to some satirical "guides" as well, which go under various names: "*Do-it-yourself CERN Courier writing kit*" (CERN Courier July p. 211 (1969), see also *More Random Walks in Science*,[1] p. 140, *A glossary for research reports* in *Metal Progress* v.71

[e]See P.J. Davis and R. Hersch's (1981) classic *The Mathematical Experience*, now in paperback (Mariner, Houghton-Mifflin).

p. 75 (1957) *A conference glossary* on p. 173 of *Proceedings of the Chemical Society* (1960) see also *More Random Walks in Science*, p. 167-168. In the kit there are four tables of phrases which can be combined on the principle of (in order) any one from table A through D in succession to give such gems as "Presuming the validity of the present approximation ... pursuit of a Nobel prize ... will sadly mean the end of ... the future of physics in Europe." *The conference glossary* is a translation guide: e.g., in a paper "Preliminary experiments have shown that ..." really means "We did it once and couldn't repeat it ..." in an oral presentation "Why do you believe ...?" really means "You're out of your mind!" *A glossary for research reports* is in a similar vein: "... of great theoretical and practical importance" really means "... interesting to me ...," "Presumably at longer times ..." means "I didn't take the trouble to find out," "While it has not been possible to provide definite answers to these questions ..." really means "The experiment didn't work out, but I figured I could at least get a publication out of it." The lesson here is to look and see to what extent your prose is subject to this kind of cynical misinterpretation.

5.2.1 Letters vs. regular papers

In general, the normal means of publication is the peer-reviewed scientific paper. Shorter publications (Research Notes, Brief Communications and the like) are *either* for more limited topics not up the weight of a regular paper — snippets, if you will — *or* for brief letter-length reports on very important topics for which rapid publication before a wide audience is deemed essential — like *STOP PRESS* bulletins. It is the usual assumption that this very important work will be followed by at least one full paper and (one should hope) several papers. (All too often, however, this is not the case. All too often what is seen instead is a series of such short publications on a given topic, with few full papers.) It is essential that in your CV these important short STOP PRESS publications are clearly identified as such, and not confused with their humbler snippet cousins. (This can easily happen because of the structure of the refereed literature.) It is worth pointing out, however, that in some disciplines and sub-disciplines (e.g. biology and engineering),

short papers and communications are not considered prestigious at all. In fact several biologist and engineer colleagues frown on our appreciation of short publications, noting that in their field "you either tell the whole story or you're not taken seriously."

Some journals publish exclusively letters or short contributions. Examples include *Applied Physics Letters* and *Physical Review Letters* for physics and chemistry, and *Chem. Comm.*, *NanoLetters* and *Angewandte Chemie* for chemists. (Scientists from other fields will kindly excuse our lack of equivalent lists for their interests. This is another item to be attended to in a second edition.) Some other journals publish both regular papers and communications in the same volume, like the *Journal of the American Chemical Society* (better known as JACS), and *Physical Review A* through *E*, with their *Rapid Communications* sections.

Standing head and shoulders above and apart from these more specialized journals are *Nature* and *Science,* the two most prestigious scientific journals. These have a section devoted to Letters (Nature) and to Reports (Science), and a shorter section devoted to Articles, which tend to be longer contributions that report major advances in a given field (each issue only contains one or two of them, on average). They also have a section on very short communications, *Briefs* (Nature) and *Brevia* (Science) which are one page in length or less.

Generally speaking, in many (but not all) disciplines, Letter journals tend to be more selective, and therefore it is more difficult to publish in them. Precisely because it is more difficult, almost everybody would like to get published in a letter journal — the added difficulty and selectivity carry extra prestige and are often associated with a higher quality. The necessity of rapid publication (the original reason for founding these journals as fast-track vehicles) is now often slighted in the weighting of the likely impact and novelty of the publication. In fact, with appeals and corrections and the like, it is not rare to have some publications in letter journals actually take longer to see the light of day than the average time to publication in the associated regular journals.

A Letter journal generally offers the advantage that your submission is often (but not always) processed faster, and that your work, if published, because of the valued *imprimatur* of a highly selective

journal, will be read more broadly (and hopefully more frequently cited). In the scientific arena, exposure of this kind is something everybody fights for. Being in the spotlight is almost everybody's dream. Peer recognition, as we keep repeating, largely determines your success.

On reflection, the tendency to write short contributions in certain disciplines is not at all surprising: most scientists, especially important and famous ones, tend to be incredibly busy, and are therefore unlikely to read long papers. Since famous scientists desperately want recognition from other famous scientists, they will invariably try to write short papers in the very best journals with the highest impact factors, so that a larger audience will read them; and so on.

Nowadays the most selective and prestigious sections in *Nature* and *Science* are called Brief Communications (Nature) and *Brevia* (Science) and they only take up about half a page and one journal page, respectively. The acceptance ratio for Nature's Brief Communications section is in fact roughly 5%, much lower than the Letters section.

Writing concisely and clearly is therefore an absolute must, particularly if you want to publish a letter. (Learning to write concisely and clearly is also useful when you apply for a fellowship or a grant, since most funding agencies provide strict guidelines about how many pages (or words) are available to write your proposal.)

It is a mark of respect for the community to write a long follow-up paper after you managed the arduous task of publishing a first letter. (This should be standard practice, but is not.) In this follow-up publication you will of course remind everyone that you just published a letter, and, more importantly, include all the experimental or theoretical details that simply could not fit into the letter format, but which are important if your work is to be thoroughly understood. This is particularly true if someone wants to reproduce your data or perform calculations based on your experimental results.

You may not want to go through the quasi-political hassle of writing a letter and arguing its way past the letter journals guard-dog referees, and you may therefore decide to write directly a long paper where the degree of hostility is lower.

Clearly, like the choice of journal in which to publish either the letter or the paper, the balance between the two is partly based on your own

estimation of how important the work is (not all ducklings are unrecognized cygnets) and partly on your own taste for battle.[f] (Some cringe from battling referees, others relish it.) It is a good idea to evaluate your personal motives in making those choices. While you may feel detached about not pushing this particular piece of research to the Letter journal standard, you may be denying your graduate student a legitimate shot at a good start in their publishing career. Ethically speaking, given work of equal merit, one should probably push harder for the work in which a student or post-doc is the first author, since the immediate impact on their careers will be greater.

When writing a paper you should be *very* critical about your work, your approach, your results and the way you are presenting them. The best way to do this is to ask yourself, how would you rate this paper if you were to review it as an anonymous referee? Would it meet the standards of the journal where you wish to submit it? Would it have a fair chance of being accepted? Many small points of clarification in a paper are inserted to forestall a pointed question by a referee. (Answer the question before it is asked.) Again, think of this as a game of chess and do your best to be several steps ahead of your opponent(s) (in this case, the referees).

Of course, being objective about your own work is the tricky part here. Any scientist who has been even modestly successful will admit that their ability to write papers improved tremendously after the first few chores of refereeing are under their belt. After that it is much easier to see the flaws in your own work and in its presentation. For this reason you should be generous about acting as a referee; you will get as much benefit as the service you render. (Besides, it looks good on your CV.) Also, if your supervisor is doing a lot of refereeing, offer to help. Most will be grateful for the offer; but once you are experienced enough, it is best to make sure that it is *you* who sends the report in to the journal and thus gets added to their list of referees. (If you do a sufficiently good job

[f]We offer the Johnston Observation of Non-Reciprocity in Refereeing. "How is it that the journal editors send me such poor stuff to referee, while my submissions often fall into the hands of refereeing numbskulls who don't know excellent work when they see it?"

of refereeing you may eventually be asked to become an Associate Editor and this is a very useful addition to your CV.)

If you do this exercise of serious self-evaluation each time you write a paper, it will usually save you a lot of time later in avoiding delays inherent in making detailed revisions which would have to be checked again by the referee. A good paper has to be thought through exhaustively and should convince you completely when you submit it. A good way to do this is to write and rewrite the paper until you really cannot stand its sight any more.[g] At this point the best thing is to leave for a week or two to "cool off" so you can regain your detachment before the taking next step. At that point, you are ready to submit, because it is unlikely that you can contribute to it any more. Another important piece of advice is to ask some colleagues (e.g. your mentor if you have one) to read it critically for you before submission. This "internal" review is important, and since it is informal and usually constructive, it is likely to save you a lot of time and frustration.

With junior colleagues as first authors, you should try to have them produce at least the first draft of the paper. After all they will have to learn eventually, so you are not doing them a favor by doing too much of the work. A strategy which often works is to sit down together and write the outline, and then send the student to write the paper from that. Of course it will not be as efficient as if you wrote it all yourself, but a very important part of the education to which the student (or a post-doc) is entitled is some training in paper writing.

As a general strategy, it is probably best to publish as many glittering Letters as you can, and, for the rest, it is better to publish a few good meaty papers rather than many average papers of modest length. (If people tend to say of your work, "Have you seen X's last paper on the "whatsit" effect?", you are publishing too many contributions so small that they risk being lost in the literature "noise." A good analogy is

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[g]**Federico:** — This typically happens to me some time after the 30th draft, however I expect that each person will have a different tolerance threshold. Incidentally, when I submitted to *Science* in December 2001, together with my co-workers we went through approximately fifty drafts, and when we got the reports from the referees and the Editor, we were asked to rewrite the paper entirely!

maritime radar, where the echo from the waves is called "sea clutter." If the boats you try to see are too small, they will be lost in the "sea clutter". (The tendency we are advocating is that of the famous German mathematician Gauss, who had as his motto (on his seal): *Pauca sed matura* (Few, but ripe). If you are not as talented as the legendary Gauss, do not go to the extent he did. Many of his results were found in his drawers after his death, because he felt that he had not yet polished them well enough.)

Publishing papers of impressive weight will improve your signal-to-noise ratio, as well as your citation rate and your overall impact. (Of course it will reduce the raw number of publications and might bring harassment from the strict publication counters.) Psychologically it will also have a positive effect, since it will make you feel good about yourself and proud of your work. In the long run, you want to look proudly at your publication list, rather than view it as a collection of papers whose sole purpose was to advance your career. Graduate students often tend to fall into what we call the "short list" syndrome. It takes them a while to publish their papers, and they feel uneasy about having a short publication list.

Federico: — I used to feel like that when I was a student. This is understandable, since this list will be a determining factor in a student's ability to find a job after graduation. This is especially true if you want to stay into basic research. However, students tend to forget that in the longer run, the quality of their work — even their very early work — will largely determine their success in science. However if someone has a few lightweight publications at the start of their career, it will not hurt them in the long run, provided that the light-weight publications are phased out as the career gets up to cruising speed. (In any case funding agencies will often ask you to present only the last five or six years of your work. "What have you done for science lately?")

5.2.2 The structure of an article/letter: Title, abstract, introduction, conclusions and references

In terms of overall structure there is little difference between a Letter and full paper, except the length and the degree of detail, so the remarks

here apply to both. The sequence given in the title above is important, because it gives the conditional browsing order in which a paper is usually scanned to be flagged for reading. A very busy scientist nowadays may not be able to go through the literature more than once or twice a month, and sometimes even less. (This is also very sad, but true.) To be flagged for reading the paper will have to elicit a "yes" from the reader at each browsing step or the browser will move on to the next paper.

In more detail, then, in browsing through journals, the reader will first skim through the titles. If the title attracts enough attention to warrant going further, the next move is to read the abstract, then the introduction, then the conclusions, and (perhaps) finally the references. (However, the references are often checked before the body of the paper to see if you have cited the reader's work, and to see if your knowledge of the literature is adequate, or perhaps even novel.) The body of the paper will often only be attacked if these preliminary indications are promising enough to make the reader think that it is worthwhile. Although you are not writing your papers exclusively to captivate and please super-busy scientists, if you do not pass these sequences of interest checkpoints, your paper will be read only by the small set of people who read everything on the topics they care about, including yours. You should want to do better than that.

The situation is like that of the store trying to lure a customer inside; the "browse" sequence being the name of the store and what it sells, any indication of a special sale, window displays, perhaps a display inside the store and finally the merchandise itself. In effect, the title should answer the implicit question in the browser's mind of each title "Why should I stop to look at this paper in more detail?"

The lesson from all this is that, when you submit a paper for publication, you should make sure that the title you choose is appropriate and captivating. It should be as short as you can make it, since longer titles are somewhat of a turn-off. (A superb title for review of some work on how frogs' eyes automatically track motion referred to a complex background was "What the Frog's Eye Tells the Frog's Brain." That is a title that is difficult to beat.) Remember that your title does not have to have too much detail, because that you can put into your abstract.

Of course, your abstract should also be short, clearly written, and should contain the main points of your paper. Your introduction (really the first paragraph if you can manage it) should place your work in its proper context, and give a broad view of why this field is important, and where it is leading.

Your conclusions are also important, because they may be the only thing most of your readers will remember. The conclusions may make the difference as to whether the paper is marked for a high-priority read, as something to come back to when there is more time, or to be copied into a running bibliography for the next paper the browser may be writing. Ideally, the concluding/summary section as well as the actual conclusions, should also point to new perspectives and directions of research. Finally, of course you should make sure that you are citing all the relevant literature, and if possible, even more. Remember, as we have said before, being generous in citing other people's work is very unlikely to do you any harm and can do much good.

Letters are so short that they require a lot of re-writing to get it right and yet keep it compact. With papers one can have dense patches for the expert and simple paragraphs to bring the less specialized reader up to speed on what is going on.

5.2.3 Dealing with referees

Having taken all the pains that you can, your *magnum opus* goes off to the selected journal and usually is returned with comments from the anonymous referees to whom you must reply (through the editor), and this is the principal topic of this subsection.

However, two other things may happen. Your work may be accepted exactly as is (a rare occurrence), in which case there is no more to be said. The editor may however declare without referee assistance that your submission is not suitable for the journal. This is most likely because the field that is being addressed is too far from the central theme of the journal, or (more rarely) because it is not up to the level that their referees need to be called to examine. In either case your dialogue is then directly with the editor whose name you know, rather than with anonymous referees, as transmitted through the editor. The dialogue is

rather different and your part resembles that of an agent arguing for his client to get a publisher to look at a book or to obtain a part in a play or the like. You are in a difficult position with little negotiating power. Diplomacy, intelligence and perhaps cunning are needed, but it is difficult to give general advice.

Of course you might run also afoul of journal style rules, which most of us cravenly obey. In connection with journal rules (admittedly some time ago), an author was told (by a colleague) that a manuscript which he was about to send to *Physical Review Letters* would have to be modified because he was the sole author and used "we" throughout. Rather than switch to "I" was then not an option and changing it to the impersonal (e.g. from "we have made mean-field calculations" to "mean-field calculations were made" etc.) was judged too awkward before the use of typewriters rather than word processors, J.H. Hetherington chose to add his cat Willard as co-author F. D. (for Felix Domesticus) Willard. The full tale is told in More Random Walks in Science[1] on pp.110-111.

In another instance, the well-known physicist David Mermin recounted at length in *Physics Today* April pp. 46-53 (1981) his cunningly planned and successful campaign to get Physical Review Letters to accept "Boojum" from Lewis Carroll's *The Hunting of the Snark* as an internationally recognized term applied to a phenomenon in liquid helium-3 in phase A. (Amusing follow-ups of the kind frequently occurring in anything related to Lewis Carroll in *Physics Today* September pp. 11-13 (1981), and March p. 96 (1982).)

Let us turn to the more usual case, which is the author-referee dialogue conducted through the editor. Clearly if only minor issues are involved the quickest way is to agree with the referee, make the changes and get on with your life. The difficulty comes when the disagreements are more serious.

Again the subject can be divided into two cases, responding in the first case to the referee who is in favor of publication, but wants specific changes with which you do not agree and in the second case to the referee who thinks the worked is so flawed as to be not worth publishing.

For both these cases, the first piece of advice is to keep your temper. Do not rant either to the editor or to the referee; it makes about as much sense as shouting at Customs or Immigration officials, or the policeman

who gives you a speeding ticket. While fair words may not succeed, foul words will most certainly fail. The second piece of advice is to try to put yourself in the referee's position and see through to the roots of the disagreement; this will be invaluable in putting your case in a conciliatory and civilized tone. The third piece of advice is to realize is that the situation now resembles a jury trial, where you are the lawyer for the defense, the referee, the prosecutor and the editor is the judge/jury. The game can be won even if you cannot convince the referee to change the opinion, because the referee may lose credibility with the editor, as being unreasonably picky or shrill or even wrong. (This is more likely to be the case if there is more than one referee and the negative opinion is not in the majority.) All this is much easier to see and to do if you have done your share of refereeing and are thus used, so to speak, to "playing the game" the other way.

This possibility of loss of credibility of the referee during the dialogue is why it is very important to appear to be patient, reasonable and, yes, even sympathetic, with a tone that reflects more sorrow at a misunderstanding by the uninformed than anger at the insolent. (Remember that implying that the referee is not competent is an implicit reproach of the editor for not knowing of the incompetence or worse of the referee. The worst that you should imply is that the referee is perhaps a little out of his depth or obsessed on this particular point. Do not, for instance, wonder how this referee could have been picked to referee your work.) It also helps to take blame for not making the points sufficiently clear, even thanking the referee for bringing this defect of presentation to your attention, and so helping you to improve the paper.

In the case of disagreement on a point which is not a simple misunderstanding to be corrected, but strong disagreement of, say, interpretation (where difference is often possible), another tactic to consider is to include the referee's comment, but maintain your point with your reasons for inclining to your view rather than that of the referee. In effect, you are saying to the editor, "There are two possibilities here and we are presenting both and leaving it up to the reader." If the referee persists the editor may well decide for your ecumenism and against the narrowness of the referee.

If the referee is really negative, while you may try these milder tactics, there are other and sterner measures. If the referee's familiarity with the field seems shaky, you may undermine the credibility of the referee, perhaps by bringing other references and authorities that you hadn't included before, perhaps by phrases such as, "these objections have been dealt with elsewhere by etc." If the referee's opinion is too vague, and too sweeping ("lacking in originality" and the like) you can with justice complain of the difficulty of defending the work against such vague accusations without supporting detail.

If all these measures fail, remember that you can often demand the opinion of another referee. This should always be done in a tone that is slightly apologetic (for putting the editor to more trouble because of this stubborn referee) but firm.

All this is quite serious and stressful, so much so that a somewhat lighter look at the topic is worthwhile including for your amusement. The item is the well-known *A Note on the Game of Refereeing* by J.M. Chambers and Agnes M. Herzberg in Applied Statistics XVII n. 3 (1968), reprinted in *More Random Walks in Science*[1] pp. 8-13, and available (2005) in downloadable form at on the Web www.buzzle.com/chapters/science-and-technology_jokes-and-funnies.asp. Unfortunately the full text would take nearly five pages here, so all we can give is a sample or two to whet your appetite for the full text.

DIVERSION Excerpts from *A Note on the Game of Refereeing*

... It is agreed that the author's objective is to have his paper published, and that extra points accrue for the publication of a particularly worthless submission. ... Likewise the referee's minimal objective is to have the paper refused and extra credit is obtained if the paper was a major contribution to the field. ...

After the opening, it is worth sampling more.

DIVERSION More excerpts from *A Note on the Game of Refereeing*

Author tactic A5: A5. Flattery-may-get-you-somewhere tactic In the revision of the paper the author thanks the referee for his "helpful comments" etc. This is very often employed against tactic R5 (deliberate misunderstanding of something which is correct) by saying something to the effect that he (the author) "agrees that he was not clear in the earlier version of the paper."

A7. Precedent tactic. Reference is made to a paper which although of very low quality was recently published in the same journal. The author implies that his work cannot be of lower quality than the previous paper. The danger, however, is that the editor may be only too aware that he should have rejected that paper and will act accordingly.

Referee tactic R2. Wrong-level tactic. No matter what degree of rigour the author uses, the referee replies by saying that it is not the correct one. For example, "The author has stressed rigour to the detriment of clarity," "The author's colloquial style is insufficiently rigorous," "The author unfortunately tries to combine rigour with a colloquial style to the detriment of both."

CONCLUSION ... It must be acknowledged that the entire practice of referee-man-ship has declined in recent years. With the publication of more and more journals, and the issuing of present journals more frequently, the pressure for papers to fill them restricts the referee from rejecting as many acceptable papers as hitherto. ... However, the most insidious cause of this decline is the loss of the true savage refereeing spirit among the modern generation of players. We fear that too many participants have taken to heart the old adage, **"Referee as you would others referee when you are writing."**

5.3 Ph.D. theses

Most people tend to consider having to write a book-length thesis as a major obstacle to their progress imposed by an unfeeling university. The thesis needs to be dealt with to get their degree and many would gladly trade it for a thesis composed of stitching the relevant papers together with a bit of integrating text. (But see below in Section 5.3.2 for our contrary opinion.) The student might also say, "If the stuff is good enough to publish shouldn't that be enough?" The short answer is "no." The student is supposed to have reached the point where they could do autonomous research; it is the student that must be examined. Hence the thesis and ritual examination and presentation are necessary.

Insofar as a thesis demonstrates anything, it is supposed to demonstrate to the thesis examiners that you actually understand what you did, appreciate the context and did not behave merely as a super-technician following your thesis advisor's directives to the letter with no thought of your own. (The flaw in this reasoning is of course that, in that case, the thesis advisor could micro-direct the writing of the thesis just as well.)

Hence the importance of the questions associated with a thesis defense, when the candidate is supposed to respond without assistance from his thesis advisor. (Since in fact theses which survive to examination are hardly ever subject to more than extensive corrections at worst, this aspect of a thesis examination is usually more formality than fact, more ritualistic than rigorous.)

In well-run doctoral system, if the advisor has missed a significant difficulty, the humane solution is to postpone the thesis defence and fix the problem(s). Thus by the time the thesis is formally defended, the serious difficulties should be all ironed out.

If you write a good thesis however, you will be performing two and perhaps three useful tasks. It is your first (and in some cases only) chance to write a *comprehensive* text on work carried out over a period of several years in useful detail.

First of all, the work in organizing all your efforts into a thesis which is far longer than any paper and which thus allows for a much

more self-sufficient treatment, will stand you in good stead when you have to write a comprehensive report later on in your career at the end of a major project.

Second, most (but not all) theses follow previous detailed work by other candidates in the same group, usually with the same thesis advisor, as you used the previous theses as a detailed guide to the development of apparatus and procedures and perhaps computer programs, now is the time to contribute your share to your advisor's group and to future students.

Third, should the work prove to be so seminal to the scientific community that others will wish to follow it in detail, then the detailed treatment in the thesis will make plain to interested readers what is only sketched in published papers.

As just indicated, writing a thesis is quite different from a scientific article, and not just because of its length. A thesis in fact is a much more comprehensive body of work than most papers. In your thesis, you should describe carefully and thoroughly all the work you carried out as a student in Prof. *Seldom Available*'s laboratory. This is a good place to include all sorts of experimental or theoretical details and approaches that for some reason or another cannot find their way into your published papers. It is also a place where you can discuss things which did not work and why, details usually squeezed out of papers by the editors' pressure to compress manuscripts. Other valuable information may include a new data analysis method that you developed, or an improvement of the experimental technique you have used.

If your contributions are very important, they can (hopefully) be published as regular papers in peer review ed journals. If on the other hand you developed something new but not terribly innovative, the right place to record it is your thesis. It may prove of value to other students and scientists later on, so it is still worthwhile to record it in some detail.

When you started your graduate studies in Prof. S. Available's lab, was there a thesis from a previous student that helped you get started, perhaps with descriptions of complicated procedures? If not, would you have benefited from having this type of information at hand? More

than anything else, science builds on to previous knowledge,[h] and in a scientific team, well written graduate theses can be extremely useful in keeping the continuity of the laboratory. Taking this to heart, you should try to make your thesis of somewhat of a do-it-yourself manual for your successors. If you write a good thesis, including a great number of details and a thorough description of the procedures you used, your work will be useful not only for you but also for the next student who takes your place in your advisor's laboratory, and continues your work from where you left it.

To sum up, your thesis is your first chance to learn how to write a comprehensive body of work, describing in detail all you have done in a period of about three (or more) years. Sometimes, a good thesis can actually be transformed (with quite some work) into a review article. Thus, you should definitely take advantage of this chance, and see it as an opportunity to learn rather than a burden. In our opinion, it is an important part of your scientific training, which eventually will earn you your doctoral degree.

If you want other scientists in your field to know you, and to appreciate your contributions fully, you may want to circulate your Ph.D. thesis among them. As a first-order approximation, your published papers will be more in demand (assuming that they are good of course). However, as we discussed above, your thesis will probably contain the detailed procedures you used and all sorts of information that will give much better clues about your maturity as a scientist, especially if someone is trying to decide whether to employ you as a post-doctoral fellow.

5.3.1 Language of the Ph.D. thesis — English!

With few exceptions, a Ph.D. thesis normally does not have a huge readership. In general it can only be understood by experts in the field, which probably limits the total audience to about 100 people *worldwide*. Thus, if you do not write your thesis in English, a language understood

[h]Remember Isaac Newton's quote: "If I have seen further, it is by standing on the shoulders of giants." (Also on the British two-pound coin.)

by any ambitious scientist, this will limit your audience even further. Although in the short term it may be seem more useful to write it in a language other than English, either because it is the language that the local students speak, or because it is your mother tongue or because you have mastered that language better than English, in the long term the opposite will likely be true and the thesis will remain of strictly local use.

Writing your thesis in English will certainly help you improve your writing skills, even if English is your native language; and this in turn will help you in most of your future scientific endeavors. Considering that English is widely accepted as the international language of communication for the Natural Sciences and Engineering, mastering this language both orally and in written form will become an asset, and in the long term it will help you succeed as a scientist. A thesis in the local language may well have a local use, but few others will be able to use it.

A final point is the following. Since so many students come from other countries, and since the language of science is English, if the next student comes from, say, India or Brazil or China, the thesis will be of immediate use to that student in a way that will not apply for a thesis written in the local language. (On the other hand, it could be argued that the effort to read a thesis in the local language may help the student to acquire competence in reading the local written language.)

Although the circumstances no longer apply, the general principles in the following anecdotes from Federico on language and science may be useful.

Federico: — In connection with this question of language, my grandfather was also a scientist (a physicist, for a change!), and he worked in Italy between 1930 and 1964, approximately. At the time, there still was no unifying language for Science, and he had to learn no less than English, French and German (and even some Russian) so that he could read the relevant papers published in foreign journals. At that time, scientists like Einstein, Heisenberg and Schrödinger published in German, whereas De Broglie published in French, Fermi in Italian and so on. Since he had to spend so much time learning other languages, clearly this slowed down his scientific progress. So you should not be surprised by my firm belief that it is a tremendous advantage to have a unifying language for the natural sciences and engineering.

Example of T.'s thesis

I was once visiting a group of colleagues in France, and I happened to be in the office of an Italian scientist, T., who has a permanent position there. He had previously done his Ph.D. at a prestigious Institute in Germany, where he had worked with one of the fathers of Surface Science. I knew his work fairly well, and had read enthusiastically his papers published in the very best journals — *Science*, *Nature* and *Physical Review Letters*. Since I was curious about certain specific aspects and details of his work, which had not appeared in his published papers, I thought I may find them in his Ph.D. thesis, which could become a useful reference for myself and other colleagues. Upon request, he proudly produced a copy of it, telling me that it had been a great achievement for him to be able to write it in German. As you can imagine, I was profoundly disappointed. Although his thesis was a small work of scientific art, I doubt that anyone else ever read it besides his advisors and his opponents. He still offered me the copy, and I politely declined.

Two European examples: Italy and Denmark

When I was a student in *Italy,* the rules for submitting a Ph.D. thesis had just changed (thankfully!). The novelty was that students could decide which language to write their thesis in (the choices were either Italian or English for the natural sciences and engineering).

This means that I did not have to apply to a committee, asking permission to write *my* thesis in English. *I just did it.* And quite honestly, in my opinion this is the best possible approach. A graduate student is supposedly a grown-up, mature person, and since the language in which his/her thesis is written will mainly have an impact on his/her life and career, it should be entirely their decision. Asking permission to a committee, on the other hand, implies that this permission may actually be denied, which I find unacceptable. Why should a committee be allowed to decide on your behalf something that will impact *your* career?

On the other hand in *Denmark,* where I worked as a post-doc toral fellow for one year and a half before moving to Canada, there is no choice: everybody has to write the thesis in English. Denmark is a very small country with an outstanding scientific tradition; most of the students who were working in my same group had already developed excellent writing skills in English, which helped them write compelling papers that were published in the very best journals.

5.3.2 Thèse par articles

In some universities one can submit a thesis consisting essentially of published papers. This is called a "*thèse par articles*" (i.e., "thesis from publications," the term we use from here onwards). To us this thesis from publications has the appearance of a thesis choice made by some particularly lazy person. A thesis by publications consists of the publications published by the student throughout his/her graduate work, together with introductory material and some conclusions, stapled together in just one file.

Our advice is to discard completely this possibility, and to opt for a full thesis instead, on the grounds that a thesis by publications is not a *real* thesis and is essentially very little more (just the "glue" text that holds it together) than the sum of its publications. It is true that the classic thesis requires much more work than the other. However, with the classic thesis you are investing your time on a useful endeavor, instead of wasting time (admittedly much less time) on something that nobody will ever read or request (except in error for a real thesis). In fact when we write something, our aim is to provide some useful information to a target readership. If on the other hand we should believe that nobody is ever likely to read what we are writing, we would be better off doing something else entirely.

There is, however, one special situation where a thesis from publications can be a useful compromise, and that is where the student's grasp of the local language is not good but that the option of writing a thesis in English is not available. In that single case a thesis from publications minimizes the amount of the local language that must be

used. However it is clear that, while easier for the candidate, as remarked above, the local utility of the thesis over the mere sum of the published papers is likely to be negligible. This is therefore an inferior compromise solution, but obviously better than nothing.

5.3.3 Structure of the Ph.D. thesis

In the introduction, you should clearly state why you embarked on this project, and what the challenges were that had to be faced when you first started. A good introduction can become excellent reference material for you and your peers.

In the body of the thesis, you should report the methodologies you have used, the issues and problems that you were confronted with, and how you set out to solve them. You should include all the details that you think are important for someone to understand your work, to reproduce your data, and to continue on from where you left the work. If you developed a new technique (e.g. fabrication, processing, characterization, data analysis, computational algorithm) this is your chance to describe it in detail, since very often there is not enough space for such a thorough description in journal articles. It should be noted that there are also cultural differences between Europe and North America in how extensive the candidate should make the review of the field. (Europeans are required to make quite extensive reviews of previous work, presumably to demonstrate that they understand it well.) It would seem best to abide by the local custom. Since there is usually no upper limit to the number of pages you can write, this is your opportunity to write extensively and exhaustively. Somewhere between 100 and 200 pages appears to be the norm.

Finally, in the conclusions you should clearly identify your contribution to the field, and outline what are the future perspectives and challenges. If you manage to do all this, you will have written a good thesis, and although it may have a more limited circulation than the papers you published in peer reviewed journals, it may actually become a useful read.

5.4 Curriculum Vitae (CVs)

As remarked at the beginning of this chapter, the CV is the traditional way to communicate your worth and provide the links to your work for such vital aspects as employment, fellowships, scholarships, prizes and the like. In general, apart from a limited number of copies of published papers and the actual text of the proposal/application, the full background is encapsulated in the CV that accompanies them.

There is no reason, however, to use one invariant form for the CV and it is a good idea to "prune the tree" of your basic source CV "tree" with its very complete "trunk" and thick "branches" to tailor it for the job it is to do. (It is much easier to select than have to chase the data afterwards for details.)

For some applications the judicious selection of your recent work is what is of interest, while for others completeness is necessary. Creating and maintaining the full CV tree is a necessary and ongoing chore, while the tailoring of the CV for particular cases is an episodic process, according to requirements. Let us first discuss the basic CV tree.

5.4.1 The CV tree, offshoot CVs and CV components

The CV is often referred to as if it was a single object, growing by accumulating, as in "I'll have to update my CV" or "That wouldn't look good on my CV." (By the way, in North America CV is often synonymous with *resumé*.) This is not true. There is indeed a central CV complex here called the *CV Tree*, with several (possibly many) *CV components*, including but not limited to the following: *Education, Employment, Teaching, Awards, Refereed Publications, Refereed Contributions, Invited Presentations, Books and Book Chapters, Seminars, Ongoing Projects, Future Plans, Collaborations, Teaching Experience, Current Students, Former Students, Funding* and whatever else might be relevant. If you are farsighted, you will continually update all the components of what comprises the *CV Tree* as changes occur. Associated with this *CV Tree* are various subsidiary or special-purpose CVs or *Offshoot* CVs created for special purposes, and these are as varied as the uses to which you might put your CV.

The point here is that for many uses only a fraction of the CV components are needed. Also in many cases not all of a particular CV component is needed, it frequently being the case that one is restricted to data such as publications or funding applications only for the last few years. Often you find you need to put a CV together in a short time, and it is much easier to do this if the components on the main CV Tree are updated regularly. Sometimes one only has to update a special-purpose Offshoot CV from a previous application without having to go back to the original CV Tree source. Let us take these CV components one by one, but before that, one question should be settled and that is the order in which the data is presented in each CV component.

Should the elements in each component be given in chronological order or in reverse chronological order? The safest way is to be redundant and to choose both and update both on a regular basis. If you are asked to provide a CV for a lifetime achievement award then the chronological ward seems only natural. However if what is of interest is only the last few years, as is often the case, then the reverse chronological order has much to recommend it, at least for publication and funding. For instance, take refereed publications (including refereed conference proceedings). One should of course maintain the chronological list (this sometimes gets complicated because papers may not appear in the order that they were submitted) with strict and immutable numbering. This has the important advantage that these numbers can be used as reference or citation numbers forever, and these permanent numbers can be used in the body of the CV when discussing accomplishments or future plans for proposals and the like. On the other hand for cases when only recent work is to be discussed, presenting the data with the most recent and most relevant first has much to recommend it. (Of course the publication numbers are prominently positioned at the left, probably in **boldface** if permitted, for ease of reference.) You add the new work at the top and drop off old work at the end. The numbers also serve to remind the reader of how many total publications you have. In the same way, a prospective employer only cares about the last one or two employers, not what you did twenty years ago, and the funding agencies have the same interest in the recent past and not the distant past. While the safest course is to maintain both orderings for all components,

but to use mostly reverse ordering in the *Offshoot* **CV**s to keep the presentations manageably short.

5.4.2 CV components

Education, Employment, Teaching, Awards, Refereed Publications, Refereed Contributions, Invited Presentations, Books and Book Chapters, Seminars, Ongoing Projects, Future Plans, Collaborations, Teaching Experience, Current Students and Post-Docs, Former Students and Post-Docs, Funding

Education This is pretty standard, but many people omit their thesis title and thesis advisor. They should be recorded on the **CV Tree** at least so that they can easily be added for a particular case.

Employment This is again standard, but still, if there are people with whom or for whom you worked, one should note the names for possible inclusion in a particular case.

Teaching While non-academic employers are not interested, universities naturally are. Again if there is someone who can usefully comment on your teaching experience, they should be included here, in case they are needed in the future.

Awards Should be indicated for all employment opportunities

Refereed Publications As discussed above, this is a key element in all CVs. The only questions in a given case is whether to give all or just the recent work, and whether one uses chronological order or reverse chronological order, whether to give paper titles, and whether to give finishing page numbers and how to order the placement of the components..

Refereed Conference Contributions Since they are refereed, they should be in the publication list with their individual numbers.

Invited Presentations Like the refereed Conference Contributions, they form part of the list of refereed publications with their individual numbers.

Books and Book Chapters Although implicitly refereed for the publisher, these are not considered original refereed publications and should not be numbered with them.

Seminars After a while the number of seminars which in content duplicate the publications becomes irksomely large. Probably one should put all the seminars in for the early years, and keep only those from the last few years (say, five or ten) after that. A more magisterial approach is to say something like "Each published paper has, on the average, been the subject of about N presentations at conferences and seminars." On the other hand you would like to note the seminars before particularly august assemblages and in prestigious institutions.

Ongoing Projects For something like a possible employment or cross-over appointment dossier, an outline of your ongoing projects is indispensable.

Future Plans For something like a possible employment or cross-over appointment dossier, an outline of your research plans is indispensable.

Collaborations For many purposes a summary of your ongoing collaborations (including institutions and researchers) helps in defining and clarifying your research activities and shows how well you are regarded by other institutions and researchers. (Of course this may well be evident if one looks carefully at the list of authors in your publications, but the aim is not to force the readers to have to dig this out by themselves.)

Teaching Experience This is indispensable for academic employment if you have not done very much of this, being preoccupied with research. Universities will always want to be reassured that you can really contribute to their teaching.

Current Students and Post-Docs This helps to indicate the size of your current empire. It is probably useful to indicate where the students were before and yet more importantly, where they end up after they leave.

Former Students and Post-Docs Again both future students and post-docs might like to consult your former people. However it is not easy to keep up with the changing addresses of former students and post-docs after they have left.

Funding Funding agencies often want to be reassured that you are not "double dipping," by getting money from two sources for the same work and using the extra money to do something else. Often a current summary of totals is enough, but this is just about as hard to keep up to date.

5.4.3 Tailoring your CV to the purpose at hand

"*Know thy neighbor*" Here is some simple advice on how to write your CV for a particular purpose, using as a resource all the CV components that you will be keeping up to date, and keeping in mind that it should be written as a function of the target audience you would like to impress. That is why it is essential that you "know your neighbor" well enough to fashion an appropriate CV for the purpose.

Writing a CV would be relatively easy if all that was required was bald listing of your assets and career to date and if the same CV would serve all purposes. In fact, writing a CV which is *well adapted* to the purpose at hand requires some thought, but the reward for this effort can be extremely important. In particular, you must be aware that you should write differently, depending on the intended recipient. For example, a CV intended to land you an interview for a faculty position should not emphasize the same achievements as a CV intended to land you a position in industry.

There are cultural differences to consider as well. As mentioned above, in a CV intended for a North American University the text should be written a lot more "aggressively" than for a CV written for a European University. In Europe it would seem that modesty is a quality that is still appreciated. If your CV indirectly boasts that you are a genius, and your reference letters support this claim, your European peers will probably wonder why you have not been invited to Stockholm yet, and perhaps frown upon you. On the other hand, if you are too modest in your CV when you send it over in North America, it will be trashed immediately, because people will think you are simply not good or ambitious enough. Therefore even cultural differences can be very important when looking for a job. Again, it is important to be aware of them and whenever possible, to use them to your advantage.

Your aim is to place yourself as best you can on the job market or in the list of applicants for a fellowship or award. Through your CV and perhaps an interview you are literally trying to *sell* yourself to a prospective employer or fellowship/award committee. You have to be convincing, because the people to whom you are applying have all your competitors to choose from, and they do not want to make a mistake in

their choice. Remember, in seeking employment, or a fellowship, or an award, it is not good enough for you to do well; you actually have to do better than everybody else! Thus, it is potentially much tougher than just passing an exam or even getting a good grade, which were your (less ambitious) aims while in school.

Your CV, or *résumé*, should begin by describing in detail what you have done, but it should also give a clear idea of where you want to go from there. If possible, try to build it up so that it shows what kind of *vision* you have for your future. Interviewers like applicants who look ahead, instead of focusing on the past. In this sense, having a glorious past is generally not enough to land you a job: in your CV and during your interview you will have to show how you intend to build on the past. Your vision does not need to be correct or even accurate, but it is very important to show that you have one, i.e. that no matter how young you are, you actually take time to look into the future and plan ahead.

The main difficulty in writing a good CV is that you have to be concise and complete at the same time. You want to tell your prospective employer about all the important stuff that you have been doing, and outline your future perspectives, but at the same time you should do it in a few pages at most (excluding your publication list, which, by contrast, will hopefully fill up many pages). Unless every single line in your CV describes a breakthrough achievement, after a few pages you will lose your audience completely, either out of sheer boredom or lack of time.

When a University advertises a new faculty position for example, it is not uncommon that the department receives more than 100 applications.

Usually each application will be composed of a cover letter, a CV, a statement of research interests, a statement of teaching philosophy, and several (typically three or four) letters of reference (usually sent separately). All in all you can expect a minimum of 10 pages to read per applicant. (This is really a minimum; we were recently part of a search committee and would say the average number of pages per applicant was about 15, with peaks of 40 pages in some particularly unfortunate cases.)

You can imagine that the selection committee will have a hard time looking through all the applications in detail, especially if they are long rather than compact.

Thus if you manage to say all you need to say, and be concise and synthetic at the same time, your CV will definitely stand out, and this will increase your chances of getting an interview (as long as there is enough substance in your past activities, of course).

On the other hand, if you write too much, unless everything you say is really important, the members of the search committee may get bored and move on to the next application in the pile. This is again related to the concept of increasing your signal to noise ratio. If you do it well, you will have a great advantage over your competitors.

Incidentally, when you submit a grant proposal, the funding agency you are requesting support from will generally require that you attach your CV to it, and they will provide strict guidelines about the format (margins, font size, etc.) and overall space you should use. Once again, you are expected to write exhaustively about yourself, but to be concise at the same time. To obtain a somewhat different perspective, read the section on scientific writing. There we describe the difference between writing a letter and a regular article. Writing accurately, concisely and exhaustively is a very useful, perhaps necessary (but not sufficient), skill to become a successful scientist.

5.5 Oral presentation and organization

Much has been written[6] on effective presentations in front of an audience with images on a screen with the presenter controlling the timing and the sequence of the images. Nonetheless there are a number of points which do not seem to be given enough emphasis when discussing scientific presentations before audiences of significant size, and these points are what we discuss next.

The first important thing in an oral presentation is to be very sure of the allotted time and never to exceed it. (It is in any case most discourteous to the other speakers (in implying that your work is much more valuable than theirs) and to the organizers to go over time.) To begin with, you will almost always have to respect severe time constraints when you *perform* at the real conference. (Small-scale working groups and workshops are often much more relaxed with respect

to time.) In fact in most meetings nowadays oral presentations are allotted between 10 and 15 minutes, including questions and discussion. We have all seen talks interrupted well before their intended end by zealous chairmen who were trying to respect the schedule. Some chairmen do it regretfully, others are most unceremonious.[i] You certainly do not want that to happen to you, both because it is embarrassing and because you would not be able to tell your whole story. (A book without its last few chapters does a bad job of getting the message across.)

To be able to deliver your talk in the allotted time, it is essential to practice your talk — or your poster presentation — at least once, possibly more, with a local audience which is *friendly*, but one charged with the task of looking for problems in the presentation, including time. If they are nice to you and grill you hard enough, there is a good chance that you will feel comfortable giving your talk in front of an arbitrary audience. This confidence will greatly increase the likelihood of a good performance. Also, this initial trial may even expose the weaknesses and occasionally the pitfalls in your work and how you present it (confusing images etc.), so it may help you to make significant improvements in the whole presentation.

Most of the advice on giving talks[6] focuses on what you should **NOT** do in a presentation. You should be clearly aware of what the most common pitfalls are. (There is some interesting, even funny literature on this subject, as, for example, "*How to give a truly terrible talk*" and "*Fifteen ways to get your audience to leave you,*" both of which can be found fairly easily by browsing the internet, i.e., *Googling* in practice.)

You should never overestimate your audience. In a sense you want to take the audience from a place in which they are comfortable to your space probably at supersonic velocity but without their realizing that they've been through the sound barrier. Like most people, although scientists like to learn new things, they do not like feeling ignorant or

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[i]Being a chairman at a conference is considered by many to be a prestigious assignment, but it is also quite onerous and tedious. You have to sit through the whole session (as opposed to roaming through other sessions, networking in the corridor or even going to the bathroom), and listen carefully so that you can ask questions in case nobody else does. You also have to keep the schedule (which is arguably your most important task) and moderate the discussion, especially if some controversy arises.

stupid (well, after all who does?). Therefore it is wise to give a broad but compact introduction, especially when giving a full seminar, describing in appropriate detail the state of the art in the field, and where your work comes in. You should explain clearly why this field is promising, perhaps what prompted you to pursue this topic, and what type of contribution you are giving. To clarify what is new in your work, you have to begin by placing it in the proper context.

In giving your presentation, you should be telling (in some sense, *selling*) a story. This means that your talk should have a clear beginning (in the form of an introduction), a middle section, and an end (in the form of conclusions and hopefully also perspectives for future work).

It is often hard to fit all your material, and to tell a good story, in the short time allotted. (A typical time slot is 10 to 15 minutes or so for an oral presentation, especially at big conferences like the APS, MRS, AVS, ACS, EPS, ECOSS etc.) Nevertheless, the rules are the same for everyone, so you should adhere to them and if possible, take advantage of them. In this sense, particularly because of this very stringent time constraint, our best advice is to try to present just *one* new idea or result.[j] If your audience goes home with a decent understanding of this one concept, you can consider it a very good accomplishment and your participation in the conference will have been worth its while.

Since time is short, you should make sure you are conveying only the really important concepts, and that you are not providing too many irrelevant details that would clutter your presentation. In fact, if your talk is appreciated, someone from the audience may come up to you *later* to ask about the details. (One easy solution is to provide a reference to a source for details, such as your e-mail address or even a presentation on your Web page.) After all, when you are finished, you definitely want the audience to remember the key points of your work, and not the petty details. If, on the other hand, you submerge your audience with an ocean of technicalities, it is unlikely that anyone will look you up later to find out more about your work.

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[j]This is also true in relation to writing articles. If you include too much information, your paper will quickly become confusing and difficult to read.

You should use simply presented graphs or images as much as possible.

Perhaps the worst offenders are theoreticians who often tend to present too many equations. These quickly become a distraction and tend to attract time-wasting remarks on their nature. The best theoretical talks we have ever heard showed little or no equations at all, and focused almost exclusively on *concepts*. It is something difficult to do when you are young and inexperienced, however this should be your aim. The sooner you learn this lesson, the better. (Also you will be implicitly display your mastery of the field by showing that you don't feel the need to have the equations in front of you in case you forget them.) (Of course, if the basis of your talk is a well-known equation with a modification, you are allowed an equation or two to make this clear, but control the urge to go further, except when your audience are in your sub-specialty.)

Experimentalists sometimes sin in a similar manner by showing far too much detail in the sections on experimental arrangements and procedures. (A neat trick in computer presentations that can be used to control the complications is to use the Power Point facility that allows you to bring objects to the screen, to show the block diagram, zoom in on particular blocks for some necessary detail, and control the temptation that arises when the whole detailed diagram is up at the outset whereupon many in the audience will be trying to understand something that is not what you are talking about. Of course this strategy can also be used by a theorist for equations.)

Be careful of color. Many men are color blind and may confuse colors you think are quite distinct. Often the lazy option of colored graphs will give some colors (such as yellow) which are hard to see particularly if the lines are thin. Complicated background color schemes can confuse the perception of foreground objects. These are all things to check in your rehearsal presentation(s).

Do not read word for word from your slides, except for a short section where you are trying to emphasize something particularly important. (Remember how irritating it can be as a spectator, when the speaker reads from something which you have already read.) Most of the time, simply commenting on certain aspects of your viewgraph is enough

to give an idea of what you mean, since your audience is presumably able to read. While it is a very good idea to prepare a guided discourse, you should not read from your notes! You are not in high school any more. You must look and sound professional.

If using actual physical transparencies (rather than using computer projection), it is often convenient to separate the transparencies by black and white paper copies, to remind you of the contents of the next transparency. These paper interleaves are also ideal for scribbling notes to yourself reminding you in writing about something that you want to mention, but which you did not put on the transparencies.

On the other hand, if using something like Microsoft Power Point, the 6-frame paper handout summaries of your talk remind you of the conceptual framework of your talk and allow for the odd note to yourself. These handouts can be cut into the individual slides which are a very convenient size for hand-sorting sorting into a different order as you are organizing your talk.

If it is possible, and if it makes sense, you should use any help you can from modern technology. Power Point is used more and more frequently these days. It enables you to couple some special effects to the actual contents of your talk. Of course you should not exaggerate — your object is to sell your science, not to distract from it.

It is always wise to bring with you conventional transparencies as a form of backup in case Power Point or the projector system fails. (Of course that version of the talk would not be able to display the clever dynamic effects available in Power Point, so you should keep that in mind when making your emergency conventional transparencies.) It happens rarely, but if it were to happen to you ... .

If you do not feel comfortable with having to give a talk in English, especially if it is not your mother tongue, you should take care to rehearse enough times so that you build up the necessary confidence. We say this in the hope of not having to sit through more talks during which the speaker is actually *reading* from a script ...! (But then again, people who "read" from memory also tend to be quite boring, even if their English is good.)

If you become a good speaker, and do good science, you will be invited to talk many times. Besides the positive effect this will have on your ego, it will also help you further your career.

We hope that the foregoing will be a useful addition to your stock of knowledge on presentations.

Another and striking point of view is that expressed by David Mermin's *alter ego* Bill Mozart in a Reference Frame piece by Mermin in the *Physics Today* issue of November (1992) on pp. 9, 11, commenting to some extent on Garland's well-known remarks[6] on talks.

Among other thought-provoking remarks there was one which was particularly striking. "Give yourself a week. If you still can find no reason why anyone not directly involved in the work should find it tediously obscure, then you should find something else to talk about. Indeed you might seriously consider finding another area of research." (Although this little fragment had been planned as a *DIVERSION* here, it seemed that it might be too sensible to characterize it as such.)

5.6 Poster organization and presentation

While much has been said about oral presentations, not a lot is available in print on *posters*. On the Web however there is a fair amount.

An appealing source is one *Advice on designing scientific posters* by Colin Purrington, (Department of Biology, Swarthmore College, Pennsylvania) evidently designed to help poster presentations for scientists (biologists) from Swarthmore: www.swarthmore.edu/NatSci/cpurrin1/posteradvice.htm. Among other excellent features there one can find references[7] to some two books (only one explicitly on posters) and five papers dealing with posters.

The particular strategies we recommend for the presentation and use of posters will now be discussed in some detail.

A poster should not be constructed by going through a talk with something like thirty images and then laying these out (one hopes in

numerical order) on a poster surface in a left-to right rows, piled top-to-bottom like a television raster. This ignores the fact that a poster session is really more like a bazaar with many competing vendors. Unlike a bazaar, however, (but in the same vein as the two-public model for your targets for texts) there are two different classes of poster (bazaar) customers. They are, roughly, the professionals (those who know quite a lot already about the topic and are interested in the important and variant details) and the amateurs (who know next to nothing). Also poster sessions can be crowded (at least locally), and this means that the lower part of a poster space may well be blocked by people and can only be seen by those in the front row, right next to the poster and presumably the most interested. This suggests the following strategy, here dubbed the *Stalactite Strategy*. (The specific implementation below is based on the use of basic building blocks in the form of the usual 8½ by 11 inch (or the European A4 format) paper images in landscape orientation — better for large print — as building blocks, easily obtained from, say, Power Point.)

The strategy is similar to that of a shop in a street. One puts the summary and spectacular images in the shop window where they can be easily seen by passers-by.

For a poster this means put this key stuff, just above head height, so passers-by can see it easily (the "shop window"). The top-line story runs from left to right and summarizes what you want to say in something like six simple landscape images. The sign-up sheet for requests and envelope for business cards should be in the farthest right column, three down from the top. Each column (four or (perhaps) five images deep) goes into more intricate detail as you go down to the bottom. Altogether this is the *stalactite* mode of presentation (remembering that stalactites are the ones that hang *down* from the cave ceiling). With a few arrows and a bit of extra text one has a poster which works in a crowd and can be understood even in the absence of the presenter (the reason for the arrows). (When filling requests for an e-mail version, the images are rearranged for a serial presentation as given by the image numbers which Power Point readily provides and which you should always use and display.)

DIVERSION Once again Stanley Harris has a relevant cartoon. Here there is no caption but a sign (inside a large cave with many people) which reads as follows: "*STALACTITES grow from the CEILING, STALAGMITES grow from FLOOR — PLEASE DO NOT ASK THE GUIDES WHICH IS WHICH.*"

(By the way, it is easy to remember (but is little recognized as a mnemonic) that the vertical part of the "t" in "stalactite" looks as if it is hanging down from a roof like a stalactite, and vice versa for the "m" in stalagmite.)

Of course, when you prepare your poster, more or less in the same way as you do when you prepare a talk or write a paper, you should make sure that you organize it in such a way that you can tell a simple, effective story when somebody shows up to hear about it. (Surprisingly, some poster presenters do not have anything prepared beforehand about their poster. This is almost insulting to the clients, somewhat like having ignorant sales clerks in your shop. Not good for sales.) A lot of people will, of course, just glance at your work and then pass on to the next poster. However some, hooked, as it were, by the top line of images, may stop and ask questions, and they are certainly entitled to hear a coherent story. In this sense, presenting (well) a poster is very similar to presenting orally. One difference is that again you should have prepared two levels of talks, one for the experts who want the newest details, methodology and the like, and the other for the tourists who are prepared to be entertained, but not too profoundly.

To make sure that the people who come to see your poster do not forget about you and your work, in addition to the sign-up sheet for requests, you should have with you some reprints (mostly for the experts) of the work you are describing in the poster, together with a considerable number of business cards with your e-mail address on them (among other things). (Business cards are a "must" at any conference and even more for a job interview.) If your visitors like your work they may actually end up reading your papers on the subject and either offering to collaborate or at least citing your results in their own work.