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How To Give a Scientific Talk, Present a Poster, and Write a Research Paper or Proposal

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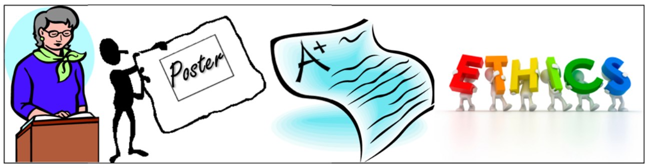

INTRODUCTION

Half of a chemist's job is oral and written communication. A professional chemist, in any employment sector, has to communicate clearly in writing and orally every day. A chemist has to write reports and manuscripts to communicate research findings (research that is not written-up is useless) and has to present "talks" to communicate research in progress. Too often, chemists (and other scientists) are given almost no instruction in communication. The following presents some suggestions on how to give scientific talks and posters and on how to get started writing research papers or proposals.

This article gives my opinions as gleaned from 45 years of reading the scientific literature, helping to edit *Environmental Science & Technology*, sitting through thousands of scientific talks, and viewing hundreds of scientific posters. These opinions are intended to jump-start your thinking about how to write and to present chemistry. They are not intended to replace the *ACS Style Guide*[1] and other how-to-write books, such as *From Research to Manuscript: A Guide to Scientific Writing*,[2] *Write Like a Chemist: A Guide and Resource*,[3] and *The Craft of Scientific Communication*.[4] These are all useful books and should be used as resources. However, in my opinion, they are all too long to be of primary use to the average chemist (particularly the average student). In addition, none of these books pay sufficient attention to the preparation of scientific talks and posters, an activity that is as important as writing in the career of most chemists.

My intended audience includes advanced undergraduates, graduate students, postdoctoral research associates, and junior faculty. I hope that each of these groups will find something useful here that will improve their communication skills. Only about half of what I have to say here is original. Brief (and unabstracted) articles about writing scientific papers and giving scientific talks have appeared in *Chemical & Engineering News*,[5−7] and I have borrowed ideas from them.

HOW TO GIVE A SCIENTIFIC TALK

Know your audience. If you are speaking at a conference, your audience will probably be made up of colleagues with backgrounds and knowledge similar to yours, so you can start your talk at a more specialized level. If you are presenting an academic seminar, your audience will probably consist of people with various specializations (perhaps not even chemists) and with different educational backgrounds. In these cases, you will need to start at a more general level to get your audience up to speed.

I find it useful to present talks as a "story," which has a beginning (introduction), a middle (data), and an end (conclusions). Putting your research in the current scientific framework by citing some (but not all) of the literature is a good way to start even if you are speaking to experienced researchers. You should explain why you did the work in the first place, and give your goals, perhaps stated as hypotheses. There is usually no need to present experimental methods in great detail or to describe the experiments in chronological order. Jump right into presenting your data, but do not overload the listener with details. Focus on the "big picture" and on the story you are telling. Do not believe the old adage, "Tell the audience what you are going to tell them, tell them, and then tell them what you told them." This approach implies that your audience cannot remember a few simple points and leads to a bored audience.

Preparing a good talk takes time, so start early. Polish the talk and the associated slides to convey your story. The best place to work on your talk is in your office or laboratory not at the hotel the night before and certainly not on the platform as you are giving it. I have seen speakers look at slides that come up during their talk as though they had not seen them before. Avoid this embarrassment. Do your heavy lifting well in advance of the deadline.

Microsoft's PowerPoint makes the preparation of excellent visual aids easy, but you should avoid using the built-in slide templates (occasionally called "chart junk"[8]); these templates tend to waste valuable space. For example, the data area in the slide on the left in Figure 1 is 75% larger than the data area in the slide on the right. In most slides, the best background is white (or "none") because its reflection from the screen adds ambient light to the presentation room, and this bit of extra light helps you see your audience. Avoid abbreviations and jargon as much as possible. Why make your audience do extra work to figure out what you are trying to say?

Visual slides (figures and pictures) are usually more effective than tables. I do not use sound, and I limit slide animation to circles and arrows, which are occasionally needed for emphasis. Be wary of having too many bullet-point slides one right after the other. Vary the visual look of your presentation by mixing text slides, pictures, tables, and figures. Be sure each slide connects logically to the next, but do not overdo it. Remember that you will be explaining these linkages as you go along. Do not read your slides to the audience, even if English is not their

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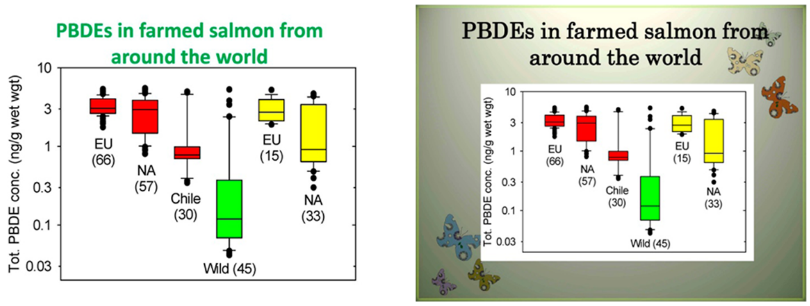

Figure 1. Two slides prepared with Microsoft's PowerPoint showing (left) the simple version and (right) the same material on a PowerPoint supplied "template". Note that the "chart junk" on the template serves only to reduce the area allocated to the data.

(or your) native language. Do not narrate your slides, as in "the next slide shows. . .".

Slides that cannot be read by the audience are of little use. Be sure to use a large enough font so that the slides can be read from a considerable distance. If you cannot read your slides on your computer screen from across your office, the font is too small (or your office is too big). Be careful with significant figures in your tables; three significant figures are usually plenty. Also be careful with units; all of the information in your figures and tables should explicitly include the units. For example, in Figure 1, the concentration units are clearly given to be ng/g wet weight. Once you think your slides are done, show them to a colleague. Feedback at this point is useful if for no other reason than to catch typographical errors that will distract your audience.

No matter what else you do, do not exceed the time scheduled for your talk. If you have been given a 20 min time slot at a conference, plan to talk for no more that 15−16 min. This will give the audience time to ask questions. If you have been given a 55 min time slot for a seminar, plan to talk for 45−50 min. Remember the audience is usually attending your talk voluntarily; do not take advantage of their good-will. Most conference presentation rooms have timers with green, yellow, and red lights to help you monitor your time consumption. Be sure you know how many minutes you have left when the yellow light comes on, and be sure you stop when the red light comes on. If you find yourself short on time, skip a slide or two; do not try to talk faster. It is more important to cover a limited amount of material clearly than to cover a lot of material poorly.

Keeping on time is particularly important for those seminars you might present as part of a job interview. Exceeding your allotted time and leaving no time for questions is an almost sure "kiss of death." No one wants to hire a colleague who cannot even follow a simple rule like "keep on time." By the way, very short (say 35 min) seminars in a job interview are almost as bad as going too long. Going too short suggests to the audience that you really do not have much to say and allows them to ask a lot of embarrassing questions.

Many speakers, particularly those whose native language is not English, find it helpful to rehearse their talks. Presenting the talk out loud to yourself helps you check the timing and learn the material. You may want to make notes of your opening remarks if you tend to be nervous when you get up to speak. On the other hand, do not rehearse your talk so many times that you have essentially memorized it, and it is a very bad idea to read your talk to your audience. You want to aim for an "extemporaneous presentation" that has been carefully prepared. That way, you can put some life into it. Try for a conversational tone in which you are explaining things to the audience rather than giving them a "speech." After gaining experience standing in front of an audience, you will become more comfortable, and your timing will be more accurate. Over a few years, you will develop your own personal style. You should aim to come across not only as competent but also as someone the audience wants to listen to.

Effective scientific talks often stimulate questions at the end. Some questions will be for clarification of some detailed point, some will be to challenge your assumptions, and some will be designed to get the questioner's name before the audience. Embrace questions. You can get good ideas about what to do next or about how to present the material more clearly the next time. It is often wise to briefly repeat the question before launching into your answer. Be careful not to make your answer so long that other questions are stifled. If your talk is presented as part of a job interview, be particularly careful with your answers. Many job candidates have been rejected because of their long-winded, arrogant, or just plain wrong answers to audience questions.

If possible, arrive at the room where you will be giving your talk a bit early to make sure that you can download your talk (which you have brought with you on a memory stick) onto the room's computer. Incidentally, it is also smart to e-mail your talk to yourself as a back-up. (I once had my memory stick stolen in a European railroad station, and I would have been struck mute if I have not taken this precaution.) The first thing you should do when you stand up to give your talk is to smile at your audience. Smiling suggests to the audience that you are happy to be speaking to them and that you care about communicating with them. Show your audience that you are having fun explaining your science to them.

Most importantly, make eye contact with your audience! How can you tell if you are getting through if you do not look at your audience? Do not speak to the screen or to the laptop computer on the podium. Use language that is as simple and as free of jargon and abbreviations as possible. The only exception is a job interview talk, which should be pitched just slightly above the heads of the audience. I have seen job candidates rejected because a member of the search committee said the work could not be that deep "because I understood it all." Avoid run-on sentences separated with "umm" or worse "you know." Humor does have a place in a scientific talk, but be careful. Do not use "joke" jokes, but the occasional bit of sarcasm is warranted. If you are normally not a witty person, there is little reason to believe that you will be a witty speaker when you stand in front of an audience.

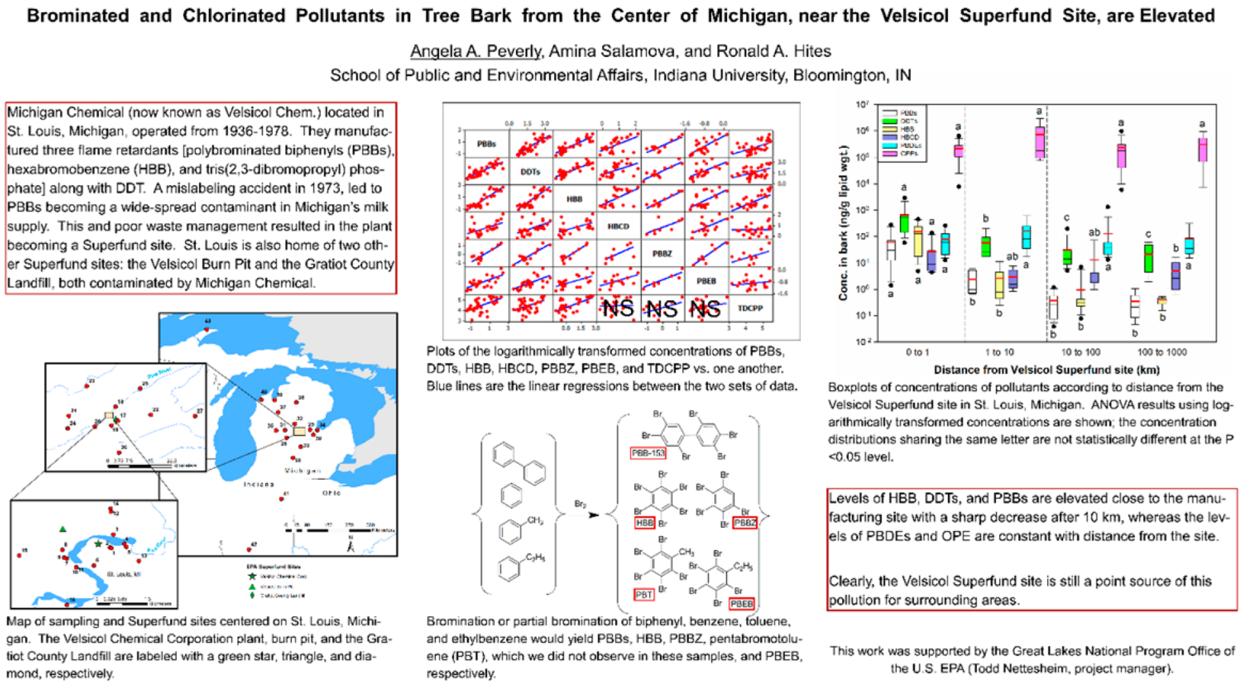

Figure 2. An example poster showing the limited use of words. The original size of the poster was 42 × 75 inches. Note that even at the size reduction shown here, the text is still readable.

HOW TO PRESENT A POSTER

Many student's first scientific presentation will be in a poster session. This is a good format; assuming people stop by your poster to chat, you will get some quick and useful feedback. Posters are not intended to be second-class presentations relative to oral presentations, so it is worth your time to prepare your poster carefully. You should use Microsoft Publisher (not PowerPoint, which limits the maximum size of the poster) to prepare your poster. Be sure you know the size and shape of the board on which you will mount your poster at the conference. Many poster sessions are now using boards that are four feet high by eight feet wide. This is the so-called landscape format. Sometimes to save room, the boards are mounted in the portrait format, and sometimes the boards are three feet wide and six feet high. It is up to you to find out what will be provided for your poster and to prepare your poster in the correct size and format. Filling most of the space allotted to your poster is generally important. Putting up a 2 × 2 ft. poster in a 4 × 8 ft. space either means that you do not have much to say or that you have used a font that is too small.

It has been my experience that the best posters are often the ones with the fewest words. An example of a poster from my laboratory is given in Figure 2. Do not put too much text in the poster—people will not read it. As with a talk, focus on the "big picture" and try to tell a story with mostly graphic elements. Start with a short abstract in the upper left, and end with the take-home message in the lower right. The title is particularly important for a poster. A good title will get people to stop and listen, but resist the temptation to be too clever or cute. A title phrased as a sentence helps the listener understand your intent. In terms of the content, the same rules apply as they do for a scientific talk: Introduce the topic and clarify the significance of what you are presenting (preferably with visual elements); tell a story with a logical sequencing of facts; give examples to illustrate your arguments; do not go overboard with details and data; and be sure to have a conclusion that summarizes your take-home message.

White-space can be helpful in structuring the poster. Color is often useful in the figures for differentiating different data sets, but be selective in your use of color. Keep all of your figures as simple as possible. Poster figures should be simpler than what you might use for a scientific paper, but they can be a bit more complex than what you might use for a scientific talk. If either a figure or table will convey the same point, use a figure. Be sure the figures and tables have captions (just like you would have in a paper but shorter) telling the viewers what is being shown in a particular element. Be sure to give the units. The font sizes should be large enough so that they can be read from at least six feet away. Sans serif fonts (such as Arial) are usually the best for readability at a distance; in any case, do not mix fonts and do not use shadowing. It is sometimes helpful to bring handouts of your poster to pass out to those who are really interested or to collect business cards so that you can send your poster directly to them afterward.

HOW TO WRITE A RESEARCH PAPER

Scientists spend far more time writing than any other single activity. We write abstracts, research papers, book chapters, research reports, funding proposals, letters of all sorts, and innumerable e-mail messages. We all live in a "publish or perish" world, and excellent writing skills are necessary to survive.

The books by Katz;[2] Robinson, Stoller, Costanza-Robinson, and Jones;[3] and Harmon and Gross[4] do a good job of guiding the novice through all of the steps of writing a scientific paper, but in my opinion, the most useful book on writing is by Strunk and White, especially Chapter 5, which gives excellent advice on good writing style.[9] I will not repeat the suggestions in any of these books, but I will add a few idiosyncratic comments.

One of your first steps should be to select the journal to which you will submit your paper. This will allow you to read a few papers in that journal for style and organization and to find the guidelines for authors. Once you have a more or less final draft of your paper, check the references to see which journal is cited the most. If the journal you are aiming at is not cited, perhaps you should consider another journal.

Avoid irritating the journal's editor. Read and follow the most recent version of the journal's guidelines for authors. These guidelines will give you valuable information about the coverage of the journal, about the expected structure of the paper, and about the maximum length of the paper. If you violate these guidelines, your paper will have less of a chance of success. For example, if the length guideline is 7000 words (and gives you details on how to count the words), do not submit a paper at 9000 words. The editor will not select the "best" 7000 words; he or she will reject the manuscript.

Author sequence in a research paper is important to most people, and it is a good idea to get this clarified at the start of the writing process. In most chemistry papers, the first author is the graduate student or postdoc who actually did the work, and the last author is the senior author, who may have had the idea in the first place and who gave final approval to submit the manuscript. If there are multiple students or postdocs involved, the sequence should be established by the senior author as early as possible. The corresponding author (the person who actually deals with the journal's editor) should be the senior author. Do not include "courtesy authors" (people who have had nothing to do with the work but who have had only an administrative role); this can become an ethical issue. Be sure all of the listed authors have seen and agreed to the final version of the paper before it is submitted. Be sure all of the people who have contributed intellectually to the work are included as authors.

Frequently, when you sit down to write a scientific paper, you have already talked about the work at one or more conferences, so the organizational heavy lifting has been done. If you have not presented the work before, the steps in writing the paper are the same as organizing a presentation: First, design the story that you want to tell; this should include a clear and brief hypothesis or goal and your approach in addressing it. Second, put together the figures and data tables that you want to use, but remember that in a paper the figures and tables can be more complicated than you could use in a talk. Third, draft the text, starting wherever you feel comfortable. The idea here is to just get going–word processing software allows you to write in any sequence that works for you. Write the abstract last. Either in the abstract or near the end of the paper, you should link your results back to the "big picture" you started with.

Many people find it useful to outline in great detail before starting; personally, I just start with the text and more or less outline as I go. Occasionally, I will do an outline after a paper is almost done to make sure that the presentation is in the right sequence. Do not let the "rules" get in your way–just write. It is easier to edit than to create.

It is well-known that the three rules for good writing are "edit, edit, and edit." Thus, be sure to allow sufficient time for revision. It helps if you can set the draft aside for a couple of weeks so that you can go back and make sure you have written what you think you have. In the pressure of writing a draft, what is in our minds sometimes does not end up on the page. English is now the *de facto* language of science. It follows that, if English is not your native language, you might want to have a native English-speaker read and edit your paper before it is submitted. If you can find an English speaker to help with your manuscript for free, that is better than nothing, but remember you often get what you pay for. There are now companies, who for a fee, will help authors translate their text into clear English, but it is ultimately the authors' responsibility to be sure the scientific content of the manuscript is correct. Do not expect the journal's editor or reviewers to fix your grammatical problems. Often the reviewers will comment that they cannot follow the paper, and the editor will reject it.

Devote almost as much attention to your figures and tables as you do the text. Aim for self-contained figures that help to simplify the ideas that you are trying to convey, and use figure captions to briefly indicate what the reader should conclude from the figure. For example, look at the caption to Figure 1 in this paper. Remember the old adage that "a picture is worth a thousand words"—if you use the picture, you do not need the thousand words.

I know this is controversial, but sometimes it helps to write in the first person rather in the passive voice. I have not seen a manuscript rejected because the author used the first person, but I have seen many manuscripts rejected because the writing was dull and unclear. In any case, use the active voice as much as possible.

Avoid undefined abbreviations; in fact, try to avoid as many abbreviations as you can. Go light on the specialized jargon. Why force the reader to keep track of unfamiliar abbreviations and jargon? They are doing you the favor of reading your paper, so make their job as easy as possible. There is no need to support every statement with a reference. If your reference list starts to exceed 40 items, you are probably doing something wrong unless you are writing a review article.

■ HOW TO WRITE A RESEARCH PROPOSAL

The same suggestions for writing a scientific paper also apply to writing a research proposal (sometimes called a grant application), but here the outcome is more critical. If you write a bad research proposal, you will not get any money and your research agenda will be (at best) delayed. If you write a bad research paper, you can always send it to a less selective journal.

To write a research proposal, follow the same steps as you would for a research paper: Leave yourself plenty of time to write. Know your audience. Keep the proposal as simple as possible. Some proposals are so "innovative" that it is hard to understand what the author wants to do. The best proposals are logical extensions of the research that you are doing now. If possible, include some experimental details and preliminary data in your proposal. Be concrete, specific, and concise in your text. Get at least one outside opinion from a colleague who has a good funding track record. Be sure to explain what you are actually going to do if you get the money.

When you start out, your research ideas will logically be derived from what you did as a graduate student and as a postdoc—no one expects you to "invent the wheel" right out of the box. However, as soon as possible, you should try to submit proposals for research that is demonstrably different from what you did with your mentors. The idea is to develop a reputation as an independent scholar within a few years. On the other hand, collaborating with a senior colleague on selected research topics is often a good way to get started with some agencies.

Schmoozing has its place in the grant acquisition world. Get to know your potential grant officers, but be selective in your interactions with them. Most of these people are not going to give you a "pre-review" of your draft proposal. However, they will usually be responsive to an e-mail or phone call and will usually tell you if your idea is within the scope of their agency. It is important to follow the proposal submission instructions; for example, missing a deadline will usually get your proposal thrown out without a reading. Expect rejection, but follow-up with the grant officer about the reasons.

With a bit of effort, you can find out how many proposals have been submitted to a particular program and the number of proposals that were funded. Dividing the later by the former is the "odds ratio" for that program. For example, within the National Science Foundation, the "odds ratio" ranges from about 10−40% depending on the field; within the National Institutes of Health, the odds of a new proposal being funded are now about 10−15%. Ironically, some programs aimed at new or "young" investigators have odds ratios that are even lower. If you have a choice, find out what the odds are and submit accordingly.

Proposals will have an associated budget to specify the total amount of money for which you are asking. The first time you put together such a budget you may be surprised at how quickly it adds up, and you may be tempted to cut your request. Resist this temptation. You should ask for sufficient funds to do the work you propose. It does you little good to get a proposal funded and then to discover that you do not have enough money to do the job. In the sciences, $100,000 per year is a typical minimum.

ETHICS IN THE PUBLICATION AND PROPOSAL PROCESSES[10]

Many journals have specific guidelines related to ethical behavior on the part of their authors, reviewers, and editors; be sure to read and abide by these guidelines. Some journals require that authors sign a specific statement or check online boxes to certify that they have not committed fraud or plagiarized text or data and that the included authors are a true list of the people who contributed to the work.

A paper cannot be submitted to more than one journal at a time. To do so, is an ethical violation and will cause your paper to be rejected by both journals. On the other hand, proposals can be submitted to more than one funding agency at a time, but you need to disclose this duplicate submission. The data, tables, figures, and text in a paper must not have been published previously, with the exception of abstracts of papers presented at conferences and figures or tables for which permission has been obtained from the copyright holder. On the other hand, you can certainly use your own published text and data in your proposals, particularly proposals for renewed or continued funding of an existing project. Different journals have different rules about putting manuscripts on the Internet before they are submitted to a journal; in some cases, this can be considered prior publication and may jeopardize the acceptance of that paper.

All authors who have a potential financial interest in the results of a paper should disclose this interest to the editors in the manuscript submittal letter. Indeed, some journals have formal checklists about disclosing potential financial conflicts. These financial interests include paid consultancies, patent interests, stock holdings, advisory positions, and board memberships. In general, interests that might detract from an author's objectivity in the presentation of a study's results should be disclosed. This disclosure is often published as part of the paper. The authors should always list the funding sources for the work presented in the paper in the acknowledgments section; this is also true for oral and poster presentations.

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Notes

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