

Editorial

Ten Simple Rules for Getting Published

Philip E. Bourne

The student council (<http://www.iscbsc.org/>) of the International Society for Computational Biology asked me to present my thoughts on getting published in the field of computational biology at the Intelligent Systems in Molecular Biology conference held in Detroit in late June of 2005. Close to 200 bright young souls (and a few not so young) crammed into a small room for what proved to be a wonderful interchange among a group of whom approximately one-half had yet to publish their first paper. The advice I gave that day I have modified and present as ten rules for getting published.

Rule 1: Read many papers, and learn from both the good and the bad work of others.

It is never too early to become a critic. Journal clubs, where you critique a paper as a group, are excellent for having this kind of dialogue. Reading at least two papers a day in detail (not just in your area of research) and thinking about their quality will also help. Being well read has another potential major benefit—it facilitates a more objective view of one's own work. It is too easy after many late nights spent in front of a computer screen and/or laboratory bench to convince yourself that your work is the best invention since sliced bread. More than likely it is not, and your mentor is prone to falling into the same trap, hence rule 2.

Rule 2: The more objective you can be about your work, the better that work will ultimately become.

Alas, some scientists will never be objective about their own work, and will never make the best scientists—learn objectivity early, the editors and reviewers have.

Rule 3: Good editors and reviewers will be objective about your work.

The quality of the editorial board is an early indicator of the review process. Look at the masthead of the

journal in which you plan to publish. Outstanding editors demand and get outstanding reviews. Put your energy into improving the quality of the manuscript *before submission*. Ideally, the reviews will improve your paper. But they will not get to imparting that advice if there are fundamental flaws.

Rule 4: If you do not write well in the English language, take lessons early; it will be invaluable later.

This is not just about grammar, but more importantly comprehension. The best papers are those in which complex ideas are expressed in a way that those who are less than immersed in the field can understand. Have you noticed that the most renowned scientists often give the most logical and simply stated yet stimulating lectures? This extends to their written work as well. Note that writing clearly is valuable, even if your ultimate career does not hinge on producing good scientific papers in English language journals. Submitted papers that are not clearly written in good English, unless the science is truly outstanding, are often rejected or at best slow to publish since they require extensive copyediting.

Rule 5: Learn to live with rejection.

A failure to be objective can make rejection harder to take, and you will be rejected. Scientific careers are full of rejection, even for the best scientists. The correct response to a paper being rejected or requiring major revision is to listen to the reviewers and respond in an objective, not subjective, manner. Reviews reflect how your paper is being judged—learn to live with it. If reviewers are unanimous about the poor quality of the paper, move on—in virtually all cases, they are right. If they request a major revision, do it and address every point they raise both in your cover letter and through obvious revisions to the text. Multiple rounds of revision are painful for all those concerned and slow the publishing process.

Rule 6: The ingredients of good science are obvious—novelty of research topic, comprehensive coverage of the relevant literature, good data, good analysis including strong statistical support, and a thought-provoking discussion. The ingredients of good science reporting are obvious—good organization, the appropriate use of tables and figures, the right length, writing to the intended audience—do not ignore the obvious.

Be objective about these ingredients when you review the first draft, and do not rely on your mentor. Get a candid opinion by having the paper read by colleagues without a vested interest in the work, including those not directly involved in the topic area.

Rule 7: Start writing the paper the day you have the idea of what questions to pursue.

Some would argue that this places too much emphasis on publishing, but it could also be argued that it helps define scope and facilitates hypothesis-driven science. The temptation of novice authors is to try to include everything they know in a paper. Your thesis is/was your kitchen sink. Your papers should be concise, and impart as much information as possible in the least number of words. Be familiar with the guide to authors and follow it, the editors and reviewers do. Maintain a good bibliographic database as you go, and read the papers in it.

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Rule 8: Become a reviewer early in your career.

Reviewing other papers will help you write better papers. To start, work with your mentors; have them give you papers they are reviewing and do the first cut at the review (most mentors will be happy to do this). Then, go through the final review that gets sent in by your mentor, and where allowed, as is true of this journal, look at the reviews others have written. This will provide an important perspective on the quality of your reviews and, hopefully, allow you to see your own work in a more objective way. You will also come to understand the review process and the quality of reviews,

which is an important ingredient in deciding where to send your paper.

Rule 9: Decide early on where to try to publish your paper.

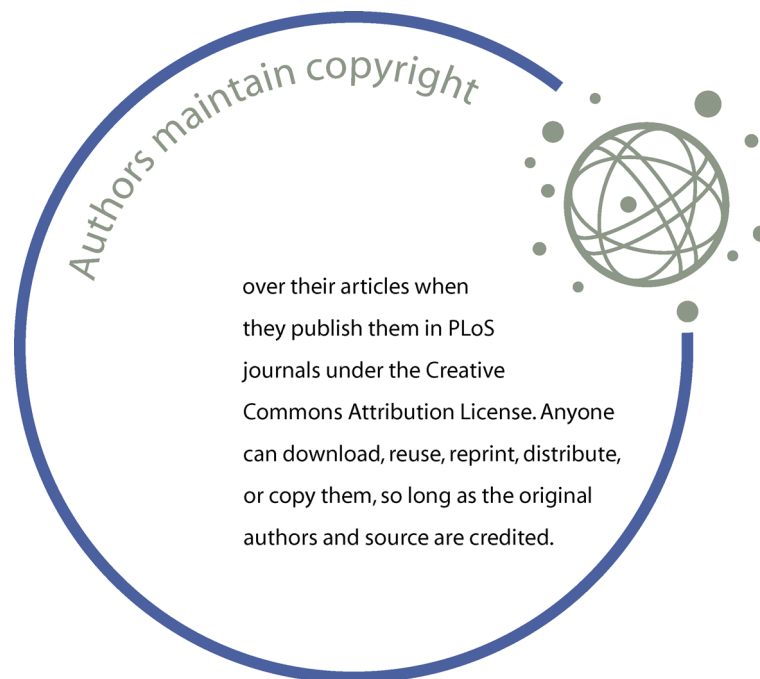
This will define the form and level of detail and assumed novelty of the work you are doing. Many journals have a presubmission enquiry system available—use it. Even before the paper is written, get a sense of the novelty of the work, and whether a specific journal will be interested.

Rule 10: Quality is everything.

It is better to publish one paper in a quality journal than multiple papers in lesser journals. Increasingly, it is harder to hide the impact of your papers; tools

like Google Scholar and the ISI Web of Science are being used by tenure committees and employers to define metrics for the quality of your work. It used to be that just the journal name was used as a metric. In the digital world, everyone knows if a paper has little impact. Try to publish in journals that have high impact factors; chances are your paper will have high impact, too, if accepted.

When you are long gone, your scientific legacy is, in large part, the literature you left behind and the impact it represents. I hope these ten simple rules can help you leave behind something future generations of scientists will admire. ■



Editorial

Ten Simple Rules for Getting Grants

Philip E. Bourne*, Leo M. Chalupa

This piece follows an earlier Editorial, “Ten Simple Rules for Getting Published” [1], which has generated significant interest, is well read, and continues to generate a variety of positive comments. That Editorial was aimed at students in the early stages of a life of scientific paper writing. This interest has prompted us to try to help scientists in making the next academic career step—becoming a young principal investigator. Leo Chalupa has joined us in putting together ten simple rules for getting grants, based on our many collective years of writing both successful and unsuccessful grants. While our grant writing efforts have been aimed mainly at United States government funding agencies, we believe the rules presented here are generic, transcending funding institutions and national boundaries.

At the present time, US funding is frequently below 10% for a given grant program. Today, more than ever, we need all the help we can get in writing successful grant proposals. We hope you find these rules useful in reaching your research career goals.

Rule 1: Be Novel, but Not Too Novel

Good science begins with new and fresh ideas. The grant writing process should be a pleasure (no, we are not kidding), for it allows you to articulate those ideas to peers who have to read your grants but not necessarily your papers. Look at grant writing as an opportunity to have an impact. Feel passionate about what you are writing—if you are not passionate about the work, it is probably not a good grant and is unlikely to get funded. “Me-too” science will not get funded when funding levels are low. On the other hand, science that is too speculative will not be supported either, particularly when funds are tight—sad but true.

Rule 2: Include the Appropriate Background and Preliminary Data as Required

You need to convince reviewers that the work you propose needs to be done

and that you are the best person to do it. Different granting programs require differing amounts of preliminary data. For certain programs, it can be said that the work must be essentially done before the grant is awarded, and that the funds are then used for the next phase of the research program. There is some truth in this. So where appropriate, do provide some tantalizing preliminary result, making sure to tell the reviewers what these results imply with respect to the specific aims of your proposal. In formulating the motivation for your proposal, make sure to cite all relevant work—there is nothing worse than not appropriately citing the work of a reviewer! Finally, convince the reviewer that you have the technical and scientific background to perform the work as proposed.

Rule 3: Find the Appropriate Funding Mechanism, Read the Associated Request for Applications Very Carefully, and Respond Specifically to the Request

Most funding organizations have specific staff to assist in finding funding opportunities, and most funding agencies have components of their Web sites designed to help investigators find the appropriate programs. Remember, programs want to give away money—the jobs of the program’s staff depend on it. The program staff can help you identify the best opportunities. If your grant does not fit a particular program, save your time and energy, and apply elsewhere, where there is a better programmatic fit.

Rule 4: Follow the Guidelines for Submission Very Carefully and Comply

Many funding bodies will immediately triage grants that do not comply with the guidelines—it saves the program time and money. This extends to all the onerous supporting material—budget justification, bibliographies, etc. Get them right and keep them updated for future applications. Even if it goes to review,

an inappropriately formulated application may aggravate the reviewers, and will have a negative impact even if the science is sound. Length and format are the most frequent offenders.

Rule 5: Obey the Three Cs—Concise, Clear, and Complete

The grant does not have to fill the allotted page count. Your goal should be to provide a complete reckoning of what is to be done, as briefly as possible. Do not rely on supplements (which may not be allowed) or on Web sites (review may be actively discouraged since it has the potential to compromise anonymity). Specify the scope up-front and make sure it is realistic with respect to the funds requested. A common temptation for inexperienced grant writers is to propose to do too much. Such applications are usually judged as overly ambitious and consequently poorly rated.

Rule 6: Remember, Reviewers Are People, Too

Typically, reviewers will have a large number of grants to review in a short period. They will easily lose concentration and miss key points of your proposal if these are buried in an overly lengthy or difficult-to-read document. Also, more than likely, not all the reviewers will be experts in your

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discipline. It is a skill to capture the interest of experts and nonexperts alike. Develop that skill. Unlike a paper, a grant provides more opportunity to apply literary skills. Historical perspectives, human interest, and humor can all be used judiciously in grants to good effect. Use formatting tricks (without disobeying rule 4), for example, underlining, bolding, etc., and restate your key points as appropriate. Each section can start with a summary of the key points.

Rule 7: Timing and Internal Review Are Important

Give yourself the appropriate lead time. We all have different approaches to deadlines. Ideally, you should complete a draft, leave sufficient time to get feedback from colleagues, and then look at the grant again yourself with a fresh eye. Having a spectrum of scientific colleagues who are similar to the likely reviewer pool critique your grant is very valuable.

Rule 8: Know Your Grant Administrator at the Institution Funding Your Grant

At the end of the day, this person is your best advocate. How well you

understand each other can make a difference. Many grant administrators have some measure (limited to complete) discretionary control over what they fund. The more they know and understand you and your work, the better your chances of success. Do not rely just on E-mail to get to know the grant administrator. Do not be intimidated. Talk to them on the telephone and at meetings where possible—they want to help.

Rule 9: Become a Grant Reviewer Early in Your Career

Being on review panels will help you write better grants. Understanding why grants get triaged before complete review, how a panel reacts to a grant, what the discretionary role of program officers is, and what the role of oversight councils is provide valuable lessons for writing successful grants of your own and for giving others advice about this process.

Rule 10: Accept Rejection and Deal with It Appropriately

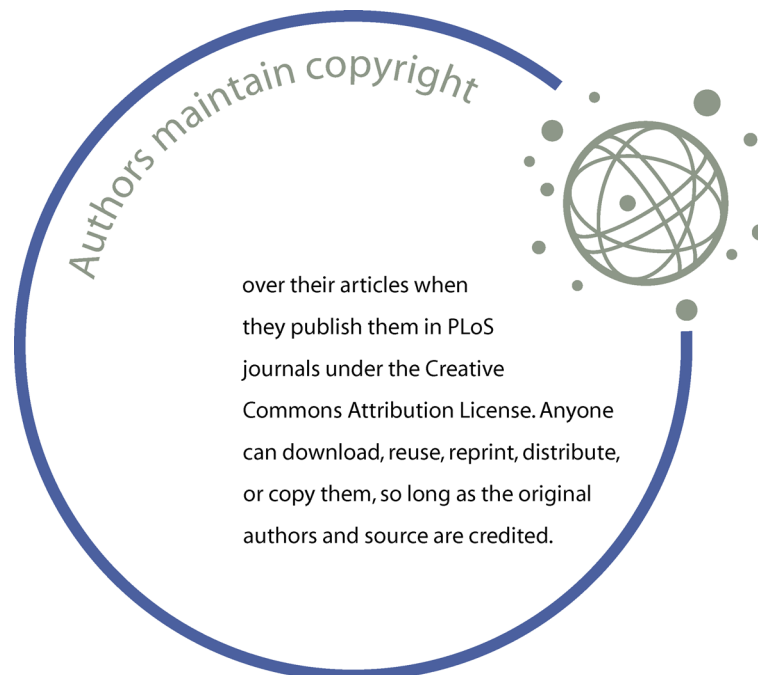
Rejection is inevitable, even for very good grants when funding levels are low. Learn to live with rejection and to respond appropriately. Do not be

defensive; address each criticism head on and respond with facts and not emotional arguments. When resubmission is necessary, make it very clear to the reviewer that you understand what was wrong the first time. Indicate precisely how you have fixed the problems. In the resubmitted application, never argue with the validity of the prior review. If the grant was close to being funded the first time around, remind the reviewers of that fact by including the previous score if appropriate, and make it crystal clear why this version is much improved.

There are no previously unrevealed secrets to grant writing presented here. Rather, it is a concise picture intended to help our early career readers take the next step. If you feel like you need more detail, take a look at Kraicer's article [2]. Good luck on getting those grants. ■

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Editorial

Ten Simple Rules for Reviewers

Philip E. Bourne*, Alon Korngreen

Last summer, the Student Council of the International Society for Computational Biology prompted an Editorial, “Ten Simple Rules for Getting Published” [1]. The interest in that piece (it has been downloaded 14,880 times thus far) prompted “Ten Simple Rules for Writing a Grant” [2]. With this third contribution, the “Ten Rules” series would seem to be established, and more rules for different audiences are in the making. *Ten Simple Rules for Reviewers* is based upon our years of experience as reviewers and as managers of the review process. Suggestions also came from PLoS staff and Editors and our research groups, the latter being new and fresh to the process of reviewing.

The rules for getting articles published included advice on becoming a reviewer early in your career. If you followed that advice, by working through your mentors who will ask you to review, you will then hopefully find these *Ten Rules for Reviewers* helpful. There is no magic formula for what constitutes a good or a bad paper—the majority of papers fall in between—so what do you look for as a reviewer? We would suggest, above all else, you are looking for what the journal you are reviewing for prides itself on. Scientific novelty—there is just too much “me-too” in scientific papers—is often the prerequisite, but not always. There is certainly a place for papers that, for example, support existing hypotheses, or provide a new or modified interpretation of an existing finding. After journal scope, it comes down to a well-presented argument and everything else described in “Ten Simple Rules for Getting Published” [1]. Once you know what to look for in a paper, the following simple reviewer guidelines we hope will be useful. Certainly (as with all *PLoS Computational Biology* material) we invite readers to use the PLoS eLetters

feature to suggest their own rules and comments on this important subject.

Rule 1: Do Not Accept a Review Assignment unless You Can Accomplish the Task in the Requested Timeframe—Learn to Say No

Late reviews are not fair to the authors, nor are they fair to journal staff. Think about this next time you have a paper under review and the reviewers are unresponsive. You do not like delays when it is your paper, neither do the authors of the paper you are reviewing. Moreover, a significant part of the cost of publishing is associated with chasing reviewers for overdue reviews. No one benefits from this process.

Rule 2: Avoid Conflict of Interest

Reviews come in various forms—anonymous, open, and double-blind, where reviewers are not revealed to the authors and authors are not revealed to reviewers. Whatever the process, act accordingly and with the highest moral principles. The cloak of anonymity is not intended to cover scientific misconduct. Do not take on the review if there is the slightest possibility of conflict of interest. Conflicts arise when, for example, the paper is poor and will likely be rejected, yet there might be good ideas that you could apply in your own research, or, someone is working dangerously close to your own next paper. Most review requests first provide the abstract and then the paper only after you accept the review assignment. In clear cases of conflict, do not request the paper. With conflict, there is often a gray area; if you are in any doubt whatsoever, consult with the Editors who have asked you to review.

Rule 3: Write Reviews You Would Be Satisfied with as an Author

Terse, ill-informed reviews reflect badly on you. Support your criticisms or praise with concrete reasons that are well laid out and logical. While you may

not be known to the authors, the Editor knows who you are, and your reviews are maintained and possibly analyzed by the publisher’s manuscript tracking system. Your profile as a reviewer is known by the journal—that profile of review quality as assessed by the Editor and of timeliness of review should be something you are proud of. Many journals, including this one, provide you with the reviews of your fellow reviewers after a paper is accepted or rejected. Read those reviews carefully and learn from them in writing your next review.

Rule 4: As a Reviewer You Are Part of the Authoring Process

Your comments, when revisions are requested, should lead to a better paper. In extreme cases, a novel finding in a paper on the verge of rejection can be saved by (often) multiple rounds of revision based on detailed reviewers’ comments and become highly cited. You are an unacknowledged partner in the success of the paper. It is always beneficial to remember that you are there to help the authors in their work, even if this means rejecting their manuscript.

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Rule 5: Be Sure to Enjoy and to Learn from the Reviewing Process

Peer review is an important community service and you should participate. Unfortunately, the more you review, in all likelihood the more you will be asked to review. Often you will be asked to review boring papers that are of no interest to you. While it is important to serve as a reviewer, only accept papers in which you are keenly interested, because either they are close to your area of research or you feel you can learn something. You might say, should I not know the work very well to be a reviewer? Often a perspective from someone in a slightly different area can be very effective in improving a paper. Do not hesitate to indicate to the Editor the perspective that you can bring to a paper (see Rule 10); s/he can then decide how to weigh your review. Editors would of course like to see you review papers even if you are not particularly interested in them, but the reality is that good reviewers must use their reviewing time wisely.

Rule 6: Develop a Method of Reviewing That Works for You

This may be different for different people. A sound approach may be to read the manuscript carefully from beginning to end before considering the review. This way you get a complete sense of the scope and novelty of the work. Then read the journal's Guide to Authors, particularly if you have not published in the journal yourself, or if the paper is a particular class of article with which you are not overly familiar, a review for example. With this broad background, you can move to analyzing the paper in detail, providing a summary statement of your findings as well as detailed comments. Use clear reasoning to justify each criticism, and highlight the good points about the work as well as the weaker points. Including citations missed by the author (not your own) is often a short

but effective way to help improve a paper. A good review touches on both major issues and minor details in the manuscript.

Rule 7: Spend Your Precious Time on Papers Worthy of a Good Review

The publish-or-perish syndrome leads to many poor papers that may not be filtered out by the Editors prior to sending it out for review. Do not spend a lot of time on poor papers (this may not be obvious when you take on the paper by reading only the abstract), but be very clear as to why you have spent limited time on the review. If there are positive aspects of a poor paper, try to find some way of encouraging the author while still being clear on the reasons for rejection.

Rule 8: Maintain the Anonymity of the Review Process if the Journal Requires It

Many of us have received reviews where it is fairly obvious who reviewed the work, sometimes because they suggest you cite their work. It is hard to maintain anonymity in small scientific communities, and you should reread your review to be sure it does not endanger the anonymity if anonymous reviews are the policy of the journal. If anonymity is the rule of the journal, do not share the manuscript with colleagues unless the Editor has given the green light. Anonymity as a journal policy is rather a religious rule—people are strongly for and against. Conform strictly to the policy defined by the journal asking you to review.

Rule 9: Write Clearly, Succinctly, and in a Neutral Tone, but Be Decisive

A poorly written review is as bad as a poorly written paper (see Rule 3). Try to be sure the Editors and the authors can understand the points you are making. A point-by-point critique is valuable since it is easy to read and to respond to. For each point, indicate how critical it is to your accepting the

paper. If English is not your strong point, have someone else read the paper and the review, but without violating other rules, particularly Rule 2. Further, as passionate as you might be about the subject of the paper, do not push your own opinion or hypotheses. Finally, give the Editors a clear answer as to your recommendation for publication. Reviewers frequently do not give a rating even when requested. Provide a rating—fence-sitting prolongs the process unnecessarily.

Rule 10: Make Use of the “Comments to Editors”

Most journals provide the opportunity to send comments to the Editors, which are not seen by the authors. Use this opportunity to provide your opinion or personal perspective of the paper in a few clear sentences. However, be sure those comments are clearly supported by your review—do not leave the Editor guessing with comments like “this really should not be published” if your review does not strongly support that statement. It is also a place where anonymity can be relaxed and reasons for decisions made clearer. For example, your decision may be based on other papers you have reviewed for the journal, which can be indicated in the Editor-only section. It is also a good place to indicate your own shortcomings, biases, etc., with regard to the content of the paper (see Rule 5). This option is used too infrequently and yet can make a great deal of difference to an Editor trying to deal with a split decision. ■

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Editorial

Ten Simple Rules for Selecting a Postdoctoral Position

Philip E. Bourne*, Iddo Friedberg

You are a PhD candidate and your thesis defense is already in sight. You have decided you would like to continue with a postdoctoral position rather than moving into industry as the next step in your career (that decision should be the subject of another “Ten Simple Rules”). Further, you already have ideas for the type of research you wish to pursue and perhaps some ideas for specific projects. Here are ten simple rules to help you make the best decisions on a research project and the laboratory in which to carry it out.

Rule 1: Select a Position that Excites You

If you find the position boring, you will not do your best work—believe us, the salary will not be what motivates you, it will be the science. Discuss the position fully with your proposed mentor, review the literature on the proposed project, and discuss it with others to get a balanced view. Try and evaluate what will be published during the process of your research. Being scooped during a postdoc can be a big setback. Just because the mentor is excited about the project does not mean you that will be six months into it.

Rule 2: Select a Laboratory That Suits Your Work and Lifestyle

If at all possible, visit the laboratory before making a decision. Laboratories vary widely in scope and size. Think about how you like to work—as part of a team, individually, with little supervision, with significant supervision (remembering that this is part of your training where you are supposed to be becoming independent), etc. Talk to other graduate students and postdoctoral fellows in the laboratory and determine the work style of the laboratory. Also, your best work is going to be done when you are happiest with the rest of your life. Does the location of the laboratory

and the surrounding environment satisfy your nonwork interests?

Rule 3: Select a Laboratory and a Project That Develop New Skills

Maximizing your versatility increases your marketability. Balance this against the need to ultimately be recognized for a particular set of contributions. Avoid strictly continuing the work you did in graduate school. A postdoctoral position is an extension of your graduate training; maximize your gain in knowledge and experience. Think very carefully before extending your graduate work into a postdoc in the same laboratory where you are now—to some professionals this raises a red flag when they look at your resume. Almost never does it maximize your gain of knowledge and experience, but that can be offset by rapid and important publications.

Rule 4: Have a Backup Plan

Do not be afraid to take risks, although keep in mind that pursuing a risky project does not mean it should be unrealistic: carefully research and plan your project. Even then, the most researched, well-thought-out, and well-planned project may fizzle; research is like that. Then what? Do you have a backup plan? Consider working on at least two projects. One to which you devote most of your time and energy and the second as a fallback. The second project should be more of the “bread and butter” type, guaranteed to generate good (if not exciting) results no matter what happens. This contradicts *Rule 1*, but that is allowed for a backup plan. For as we see in *Rule 5*, you need tangible outcomes.

Rule 5: Choose a Project with Tangible Outcomes That Match Your Career Goals

For a future in academia, the most tangible outcomes are publications,

followed by more publications. Does the laboratory you are entering have a track record in producing high-quality publications? Is your future mentor well-respected and recognized by the community? Talk to postdocs who have left the laboratory and find out. If the mentor is young, does s/he have the promise of providing those outcomes? Strive to have at least one quality publication per year.

Rule 6: Negotiate First Authorship before You Start

The average number of authors on a paper has continued to rise over the years: a sign that science continues to become more collaborative. This is good for science, but how does it impact your career prospects? Think of it this way. If you are not the first author on a paper, your contribution is viewed as $1/n$ where n is the number of authors. Journals such as this one try to document each author's contributions; this is a relatively new concept, and few people pay any attention to it. Have an understanding with your mentor on your likelihood of first authorship before you start a project. It is best to tackle this problem early during the interview process and to achieve an

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understanding; this prevents conflicts and disappointments later on. Don't be shy about speaking frankly on this issue. This is particularly important when you are joining an ongoing study.

Rule 7: The Time in a Postdoctoral Fellowship Should Be Finite

Mentors favor postdocs second only to students. Why? Postdocs are second only to students in providing a talented labor pool for the least possible cost. If you are good, your mentor may want you to postdoc for a long period. Three years in any postdoc is probably enough. Three years often corresponds to the length of a grant that pays the postdoctoral fellowship, so the grant may define the duration. Definitely find out about the source and duration of funding before accepting a position. Be very wary about accepting one-year appointments. Be aware that the length of a postdoc will likely be governed by the prevailing job market. When the job market is good, assistant professorships and suitable positions in industry will mean you can transition early to the next stage of your career. Since the job market even a year out is unpredictable, having at least the

option of a three-year postdoc fellowship is desirable.

Rule 8: Evaluate the Growth Path

Many independent researchers continue the research they started during their postdoc well into their first years as assistant professors, and they may continue the same line of work in industry, too. When researching the field you are about to enter, consider how much has been done already, how much you can contribute in your postdoc, and whether you could take it with you after your postdoc. This should be discussed with your mentor as part of an ongoing open dialog, since in the future you may be competing against your mentor. A good mentor will understand, as should you, that your horizon is independence—your own future lab, as a group leader, etc.

Rule 9: Strive to Get Your Own Money

The ease of getting a postdoc is correlated with the amount of independent research monies available. When grants are hard to get, so are postdocs. Entering a position with your

own financing gives you a level of independence and an important extra line on your resume. This requires forward thinking, since most sources of funding come from a joint application with the person who will mentor you as a postdoc. Few graduate students think about applying for postdoctoral fellowships in a timely way. Even if you do not apply for funding early, it remains an attractive option, even after your postdoc has started with a different funding source. Choosing one to two potential mentors and writing a grant at least a year before you will graduate is recommended.

Rule 10: Learn to Recognize Opportunities

New areas of science emerge and become hot very quickly. Getting involved in an area early on has advantages, since you will be more easily recognized. Consider a laboratory and mentor that have a track record in pioneering new areas or at least the promise to do so. ■

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Editorial

Ten Simple Rules for a Successful Collaboration

Quentin Vicens, Philip E. Bourne*

Scientific research has always been a collaborative undertaking, and this is particularly true today. For example, between 1981 and 2001, the average number of coauthors on a paper for the Proceedings of the National Academy of Sciences U S A rose from 3.9 to 8.4 [1]. Why the increase? Biology has always been considered the study of living systems; many of us now think of it as the study of complex systems. Understanding this complexity requires experts in many different domains. In short, these days success in being a biologist depends more on one's ability to collaborate than ever before. The Medical Research Centers in the United Kingdom figured this out long ago, and the new Janelia Farm research campus of the Howard Hughes Medical Institute in the United States has got the idea, as it strongly promotes intra- and inter-institutional collaborations [2].

Given that collaboration is crucial, how do you go about picking the right collaborators, and how can you best make the collaboration work? Here are ten simple rules based on our experience that we hope will help. Additional suggestions can be found in the references [3,4]. Above all, keep in mind that these rules are for both you and your collaborators. Always remember to treat your collaborators as you would want to be treated yourself—empathy is key.

Rule 1: Do Not Be Lured into Just Any Collaboration

Learn to say no, even if it is to an attractive grant that would involve significant amounts of money and/or if it is a collaboration with someone more established and well-known. It is easier to say no at the beginning—the longer an ill-fated collaboration drags on, the harder it is to sever, and the worse it will be in the end. Enter a collaboration because of a shared passion for the science, not just because you think

getting that grant or working with this person would look good on your curriculum vitae. Attending meetings is a perfect opportunity to interact with people who have shared interests [5]. Take time to consider all aspects of the potential collaboration. Ask yourself, will this collaboration really make a difference in my research? Does this grant constitute a valid motivation to seek out that collaboration? Do I have the expertise required to tackle the proposed tasks? What priority will this teamwork have for me? Will I be able to deliver on time? If the answer is no for even one of these questions, the collaboration could be ill-fated.

Enter a collaboration because of a shared passion for the science . . .

Rule 2: Decide at the Beginning Who Will Work on What Tasks

Carefully establishing the purpose of the collaboration and delegating responsibilities is priceless. Often the collaboration will be defined by a grant. In that case, revisit the specific aims regularly and be sure the respective responsibilities are being met. Otherwise, consider writing a memo of understanding, or, if that is too formal, at least an e-mail about who is responsible for what. Given the delegation of tasks, discuss expectations for authorship early in the work. Having said that, leave room for evolution over the course of the collaboration. New ideas will arise. Have a mutual understanding up-front such that these ideas can be embraced as an extension of the original collaboration. Discuss adjustments to the timelines and the order of authors on the final published paper, accordingly. In any case, be comfortable with the anticipated credit

you will get from the work. The history of science is littered with stories of unacknowledged contributions.

Rule 3: Stick to Your Tasks

Scientific research is such that every answered question begs a number of new questions to be answered. Do not digress into these new questions without first discussing them with your collaborators. Do not change your initial plans without discussing the change with your collaborators. Thinking they will be pleased with your new approach or innovation is often misplaced and can lead to conflict.

Rule 4: Be Open and Honest

Share data, protocols, materials, etc., and make papers accessible prior to publication. Remain available. A trusting relationship is important for the collaborative understanding of the problem being tackled and for the subsequent joint thinking throughout the evolution of the collaboration.

Rule 5: Feel Respect, Get Respect

If you do not have respect for the scientific work of your collaborators, you should definitely not be collaborating. Respect here especially means playing by Rules 2–4. If you do not respect your collaborators, it will show. Likewise, if they don't respect you. Look for the signs. The signs will depend on the personality of your

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collaborators and range from being aggressive to being passive-aggressive. For example, getting your tasks done in a timely manner should be your priority. There is nothing more frustrating for your collaborators than to have to throttle their progress while they are waiting for you to send them your data. Showing respect would be to inform your collaborator when you cannot make a previously agreed-upon deadline, so that other arrangements can be made.

Rule 6: Communicate, Communicate, and Communicate

Consistent communication with your collaborators is the best way to make sure the partnership is going in the planned direction. Nothing new here, it is the same as for friendship and marriage. Communication is always better face-to-face if possible, for example by traveling to meet your collaborators, or by scheduling discussion related to your collaborations during conferences that the people involved will attend. Synchronous communication by telephone or video teleconferencing is preferred over asynchronous collaboration by e-mail (data could be exchanged by e-mail prior to a call so that everyone can refer to the data while talking).

Rule 7: Protect Yourself from a Collaboration That Turns Sour

The excitement of a new collaboration can often quickly dissipate as the first hurdles to any new project appear. The direct consequence can be a progressive lack of interest and focus to get the job done. To avoid the subsequent frustrations and resentment that could even impact your work in general, give three chances to your collaborators to get back on track. After all, your collaborators could just be having a difficult time for reasons

outside of their control and unanticipated at the time the collaboration started. After three chances, if it feels like the collaboration cannot be saved, move on. At that point try to minimize the role of your collaborators in your work: think carefully about the most basic help you need from them and get it while you can (e.g., when having a phone call or a meeting in person). You may still need to deal with the co-authorship, but hopefully for one paper only!

Rule 8: Always Acknowledge and Cite Your Collaborators

This applies as soon as you mention preliminary results. Be clear on who undertook what aspect of the work being reported. Additionally, citing your collaborators can reveal your dynamism and your skills at developing prosperous professional relationships. This skill will be valued by your peers throughout your career.

Rule 9: Seek Advice from Experienced Scientists

Even though you may not encounter severe difficulties that would result in the failure of the partnership, each collaboration will come with a particular set of challenges. To overcome these obstacles, interact with colleagues not involved in the work, such as your former advisors or professors in your department who have probably been through all kinds of collaborations. They will offer insightful advice that will help you move beyond the current crisis. Remember, however, that a crisis can occasionally lead to a breakthrough. Do not, therefore, give up on the collaboration too easily.

Rule 10: If Your Collaboration Satisfies You, Keep It Going

Ever wondered why a pair of authors has published so many papers together?

Well, it is like any good recipe: when you find one that works, you cook it again and again. Successful teamwork will tend to keep flourishing—the first paper will stimulate deeper and/or broader studies that will in turn lead to more papers. As you get to know your collaborators, you begin to understand work habits, strengths but also weaknesses, as well as respective areas of knowledge. Accepting these things and working together can make the work advance rapidly, but do not hurry: it takes time and effort from both sides to get to this point.

Collaborations often come unexpectedly, just like this one. One of us (PEB) as Editor-in-Chief was approached not just with the idea for these Ten Rules, but with a draft set of rules that needed only minor reworking. As you can see, we have obeyed Rule 8. ■

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Editorial

Ten Simple Rules for Making Good Oral Presentations

Philip E. Bourne

Continuing our “Ten Simple Rules” series [1–5], we consider here what it takes to make a good oral presentation. While the rules apply broadly across disciplines, they are certainly important from the perspective of this readership. Clear and logical delivery of your ideas and scientific results is an important component of a successful scientific career. Presentations encourage broader dissemination of your work and highlight work that may not receive attention in written form.

Rule 1: Talk to the Audience

We do not mean face the audience, although gaining eye contact with as many people as possible when you present is important since it adds a level of intimacy and comfort to the presentation. We mean prepare presentations that address the target audience. Be sure you know who your audience is—what are their backgrounds and knowledge level of the material you are presenting and what they are hoping to get out of the presentation? Off-topic presentations are usually boring and will not endear you to the audience. Deliver what the audience wants to hear.

Rule 2: Less is More

A common mistake of inexperienced presenters is to try to say too much. They feel the need to prove themselves by proving to the audience that they know a lot. As a result, the main message is often lost, and valuable question time is usually curtailed. Your knowledge of the subject is best expressed through a clear and concise presentation that is provocative and leads to a dialog during the question-and-answer session when the audience becomes active participants. At that point, your knowledge of the material will likely become clear. If you do not get any questions, then you have not been following the other rules. Most likely,

your presentation was either incomprehensible or trite. A side effect of too much material is that you talk too quickly, another ingredient of a lost message.

Rule 3: Only Talk When You Have Something to Say

Do not be overzealous about what you think you will have available to present when the time comes. Research never goes as fast as you would like. Remember the audience's time is precious and should not be abused by presentation of uninteresting preliminary material.

Rule 4: Make the Take-Home Message Persistent

A good rule of thumb would seem to be that if you ask a member of the audience a week later about your presentation, they should be able to remember three points. If these are the key points you were trying to get across, you have done a good job. If they can remember any three points, but not the key points, then your emphasis was wrong. It is obvious what it means if they cannot recall three points!

Rule 5: Be Logical

Think of the presentation as a story. There is a logical flow—a clear beginning, middle, and an end. You set the stage (beginning), you tell the story (middle), and you have a big finish (the end) where the take-home message is clearly understood.

Rule 6: Treat the Floor as a Stage

Presentations should be entertaining, but do not overdo it and do know your limits. If you are not humorous by nature, do not try and be humorous. If you are not good at telling anecdotes, do not try and tell anecdotes, and so on. A good entertainer will captivate the audience and increase the likelihood of obeying Rule 4.

Rule 7: Practice and Time Your Presentation

This is particularly important for inexperienced presenters. Even more important, when you give the presentation, stick to what you practice. It is common to deviate, and even worse to start presenting material that you know less about than the audience does. The more you practice, the less likely you will be to go off on tangents. Visual cues help here. The more presentations you give, the better you are going to get. In a scientific environment, take every opportunity to do journal club and become a teaching assistant if it allows you to present. An important talk should not be given for the first time to an audience of peers. You should have delivered it to your research collaborators who will be kinder and gentler but still point out obvious discrepancies. Laboratory group meetings are a fine forum for this.

Rule 8: Use Visuals Sparingly but Effectively

Presenters have different styles of presenting. Some can captivate the audience with no visuals (rare); others require visual cues and in addition, depending on the material, may not be able to present a particular topic well without the appropriate visuals such as graphs and charts. Preparing good visual materials will be the subject of a further Ten Simple Rules. Rule 7 will

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help you to define the right number of visuals for a particular presentation. A useful rule of thumb for us is if you have more than one visual for each minute you are talking, you have too many and you will run over time. Obviously some visuals are quick, others take time to get the message across; again Rule 7 will help. Avoid reading the visual unless you wish to emphasize the point explicitly, the audience can read, too! The visual should support what you are saying either for emphasis or with data to prove the verbal point. Finally, do not overload the visual. Make the points few and clear.

Rule 9: Review Audio and/or Video of Your Presentations

There is nothing more effective than listening to, or listening to and viewing, a presentation you have made. Violations of the other rules will become obvious. Seeing what is wrong is easy, correcting it the next time around is not. You will likely need to break bad habits that lead to the

violation of the other rules. Work hard on breaking bad habits; it is important.

Rule 10: Provide Appropriate Acknowledgments

People love to be acknowledged for their contributions. Having many gratuitous acknowledgements degrades the people who actually contributed. If you defy Rule 7, then you will not be able to acknowledge people and organizations appropriately, as you will run out of time. It is often appropriate to acknowledge people at the beginning or at the point of their contribution so that their contributions are very clear.

As a final word of caution, we have found that even in following the Ten Simple Rules (or perhaps thinking we are following them), the outcome of a presentation is not always guaranteed. Audience–presenter dynamics are hard to predict even though the metric of depth and intensity of questions and off-line followup provide excellent indicators. Sometimes you are sure a

presentation will go well, and afterward you feel it did not go well. Other times you dread what the audience will think, and you come away pleased as punch. Such is life. As always, we welcome your comments on these Ten Simple Rules by Reader Response. ■

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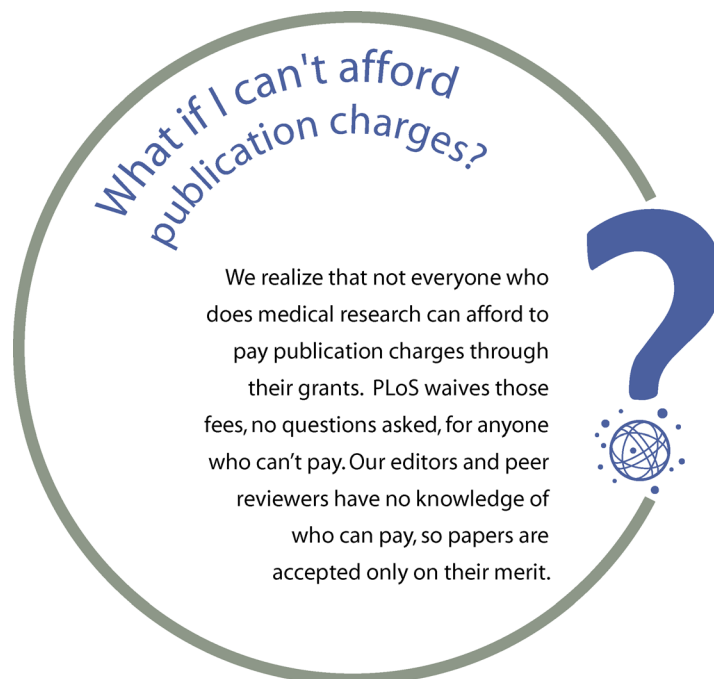
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Editorial

Ten Simple Rules for a Good Poster Presentation

Thomas C. Erren*, Philip E. Bourne

Posters are a key component of communicating your science and an important element in a successful scientific career. Posters, while delivering the same high-quality science, offer a different medium from either oral presentations [1] or published papers [2], and should be treated accordingly. Posters should be considered a snapshot of your work intended to engage colleagues in a dialog about the work, or, if you are not present, to be a summary that will encourage the reader to want to learn more. Many a lifelong collaboration [3] has begun in front of a poster board. Here are ten simple rules for maximizing the return on the time-consuming process of preparing and presenting an effective poster.

Rule 1: Define the Purpose

The purpose will vary depending on the status and nature of the work being presented, as well as the intent. Some posters are designed to be used again and again; for example, those making conference attendees aware of a shared resource. Others will likely be used once at a conference and then be relegated to the wall in the laboratory. Before you start preparing the poster, ask yourself the following questions: What do you want the person passing by your poster to do? Engage in a discussion about the content? Learn enough to go off and want to try something for themselves? Want to collaborate? All the above, or none of the above but something else? Style your poster accordingly.

Rule 2: Sell Your Work in Ten Seconds

Some conferences will present hundreds of posters; you will need to fight for attention. The first impressions of your poster, and to a lesser extent what you might say when standing in front of it, are crucial. It is analogous to being in an elevator and having a few seconds to peak someone's interest before they get off. The sad

truth is that you have to sell your work. One approach is to pose your work as addressing a decisive question, which you then address as best you can. Once you have posed the question, which may well also be the motivation for the study, the focus of your poster should be on addressing that question in a clear and concise way.

Rule 3: The Title Is Important

The title is a good way to sell your work. It may be the only thing the conference attendee sees before they reach your poster. The title should make them want to come and visit. The title might pose a decisive question, define the scope of the study, or hint at a new finding. Above all, the title should be short and comprehensible to a broad audience. The title is your equivalent of a newspaper headline—short, sharp, and compelling.

Rule 4: Poster Acceptance Means Nothing

Do not take the acceptance of a poster as an endorsement of your work. Conferences need attendees to be financially viable. Many attendees who are there on grants cannot justify attending a conference unless they present. There are a small number of speaking slots compared with attendees. How to solve the dilemma? Enter posters; this way everyone can present. In other words, your poster has not been endorsed, just accepted. To get endorsement from your peers, do good science and present it well on the poster.

Rule 5: Many of the Rules for Writing a Good Paper Apply to Posters, Too

Identify your audience and provide the appropriate scope and depth of content. If the conference includes nonspecialists, cater to them. Just as the abstract of a paper needs to be a succinct summary of the motivation,

hypothesis to be tested, major results, and conclusions, so does your poster.

Rule 6: Good Posters Have Unique Features Not Pertinent to Papers

The amount of material presented in a paper far outweighs what is presented on a poster. A poster requires you to distill the work, yet not lose the message or the logical flow. Posters need to be viewed from a distance, but can take advantage of your presence. Posters can be used as a distribution medium for copies of associated papers, supplementary information, and other handouts. Posters allow you to be more speculative. Often only the titles or at most the abstracts of posters can be considered published; that is, widely distributed. Mostly, they may never be seen again. There is the opportunity to say more than you would in the traditional literature, which for all intents and purposes will be part of the immutable record. Take advantage of these unique features.

Rule 7: Layout and Format Are Critical

Pop musician Keith Richards put the matter well in an interview with *Der Spiegel* [4]: “If you are a painter, then the most important thing is the bare canvas. A good painter will never cover all the space but will always leave some

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blank. My canvas is silence.” Your canvas as poster presenter is also white space. Guide the passerby’s eyes from one succinct frame to another in a logical fashion from beginning to end. Unlike the literature, which is linear by virtue of one page following another, the reader of a poster is free to wander over the pages as if they are tacked to the poster board in a random order. Guide the reader with arrows, numbering, or whatever else makes sense in getting them to move from one logical step to another. Try to do this guiding in an unusual and eye-catching way. Look for appropriate layouts in the posters of others and adopt some of their approaches. Finally, never use less than a size 24 point font, and make sure the main points can be read at eye level.

Rule 8: Content Is Important, but Keep It Concise

Everything on the poster should help convey the message. The text must conform to the norms of sound scientific reporting: clarity, precision of expression, and economy of words. The latter is particularly important for posters because of their inherent space limitations. Use of first-rate pictorial material to illustrate a poster can sometimes transform what would otherwise be a bewildering mass of complex data into a coherent and convincing story. One carefully produced chart or graph often says more than hundreds of words. Use graphics for “clear portrayal of complexity” [5], not to impress (and possibly bewilder) viewers with complex artistry. Allow a figure to be viewed in both a superficial and a detailed way. For example, a large table might have bold swaths of color indicating relative contributions from different categories, and the smaller text in the table would provide gritty details for those who want them. Likewise, a graph could provide a bold trend line (with its interpretation clearly and concisely stated), and also have many detailed points with error bars. Have a clear and obvious set of conclusions—after the abstract, this is

where the passerby’s eyes will wander. Only then will they go to the results, followed by the methods.

Rule 9: Posters Should Have Your Personality

A poster is a different medium from a paper, which is conventionally dry and impersonal. Think of your poster as an extension of your personality. Use it to draw the passerby to take a closer look or to want to talk to you. Scientific collaboration often starts for reasons other than the shared scientific interest, such as a personal interest. A photo of you on the poster not only helps someone find you at the conference when you are not at the poster, it can also be used to illustrate a hobby or an interest that can open a conversation.

Rule 10: The Impact of a Poster Happens Both During and After the Poster Session

When the considerable effort of making a poster is done, do not blow it on presentation day by failing to have the poster achieve maximum impact. This requires the right presenter–audience interaction. Work to get a crowd by being engaging; one engaged viewer will attract others. Don’t badger people, let them read. Be ready with Rule 2. Work all the audience at once, do not leave visitors waiting for your attention. Make eye contact with every visitor.

Make it easy for a conference attendee to contact you afterward. Have copies of relevant papers on hand as well as copies of the poster on standard-sized paper. For work that is more mature, have the poster online and make the URL available as a handout. Have your e-mail and other demographics clearly displayed. Follow up with people who come to the poster by having a signup sheet.

The visitor is more likely to remember you than the content of your poster. Make yourself easy to remember. As the host of the work presented on the poster, be attentive, open, and curious, and self-confident but never arrogant and aggressive.

Leave the visitors space and time—they can “travel” through your poster at their own discretion and pace. If a visitor asks a question, talk simply and openly about the work. This is likely your opportunity to get feedback on the work before it goes to publication. Better to be tripped up in front of your poster than by a reviewer of the manuscript.

Good posters and their presentations can improve your reputation, both within and outside your working group and institution, and may also contribute to a certain scientific freedom. Poster prizes count when peers look at your resume.

These ten rules will hopefully help you in preparing better posters. For a more humorous view on what not to do in preparing a poster, see [6], and for further information, including the opportunity to practice your German, see [7]. ■

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Editorial

Ten Simple Rules for Doing Your Best Research, According to Hamming

Thomas C. Erren*, Paul Cullen, Michael Erren, Philip E. Bourne

This editorial can be considered the preface to the “Ten Simple Rules” series [1–7]. The rules presented here are somewhat philosophical and behavioural rather than concrete suggestions for how to tackle a particular scientific professional activity such as writing a paper or a grant. The thoughts presented are not our own; rather, we condense and annotate some excellent and timeless suggestions made by the mathematician Richard Hamming two decades ago on how to do “first-class research” [8]. As far as we know, the transcript of the Bell Communications Research Colloquium Seminar provided by Dr. Kaiser [8] was never formally published, so that Dr. Hamming’s thoughts are not as widely known as they deserve to be. By distilling these thoughts into something that can be thought of as “Ten Simple Rules,” we hope to bring these ideas to broader attention.

Hamming’s 1986 talk was remarkable. In “You and Your Research,” he addressed the question: How can scientists do great research, i.e., Nobel-Prize-type work? His insights were based on more than forty years of research as a pioneer of computer science and telecommunications who had the privilege of interacting with such luminaries as the physicists Richard Feynman, Enrico Fermi, Edward Teller, Robert Oppenheimer, Hans Bethe, and Walter Brattain, with Claude Shannon, “the father of information theory,” and with the statistician John Tukey. Hamming “became very interested in the difference between those who do and those who might have done,” and he offered a number of answers to the question “why . . . so few scientists make significant contributions and so many are forgotten in the long run?” We have condensed Hamming’s talk into the ten rules listed below:

Rule 1: Drop Modesty

To quote Hamming: “Say to yourself: ‘Yes, I would like to do first-class work.’ Our society frowns on people who set out to do really good work. But you should say to yourself: ‘Yes, I would like to do something significant.’”

Rule 2: Prepare Your Mind

Many think that great science is the result of good luck, but luck is nothing but the marriage of opportunity and preparation. Hamming cites Pasteur’s adage that “luck favours the prepared mind.”

Rule 3: Age Is Important

Einstein did things very early, and all the “quantum mechanic fellows,” as well as most mathematicians and astrophysicists, were, as Hamming notes, “disgustingly young” when they did their best work. On the other hand, in the fields of music, politics, and literature, the protagonists often produce what we consider their best work late in life.

Rule 4: Brains Are Not Enough, You Also Need Courage

Great scientists have more than just brainpower. To again cite Hamming: “Once you get your courage up and believe that you can do important things, then you can. If you think you can’t, almost surely you are not going to. Great scientists will go forward under incredible circumstances; they think and continue to think.”

Rule 5: Make the Best of Your Working Conditions

To paraphrase Hamming, what most people think are the best working conditions clearly are not, because people are often most productive when working conditions are bad. One of the better times of the Cambridge Physical Laboratories was when they worked practically in shacks—they did some of

the best physics ever. By turning the problem around a bit, great scientists often transform an apparent defect into an asset. “It is a poor workman who blames his tools—the good man gets on with the job, given what he’s got, and gets the best answer he can.”

Rule 6: Work Hard and Effectively

Most great scientists have tremendous drive, and most of us would be surprised how much we would know if we worked as hard as some great scientists did for many years. As Hamming says: “Knowledge and productivity are like compound interest. Given two people with exactly the same ability, the one person who manages day in and day out to get in one more hour of thinking will be tremendously more productive over a lifetime.” But, Hamming notes, hard work alone is not enough—it must be applied sensibly.

Rule 7: Believe and Doubt Your Hypothesis at the Same Time

Great scientists tolerate ambiguity. They believe the theory enough to go

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ahead; they doubt it enough to notice the errors and faults so they can step forward and create the new replacement theory. As Hamming says: “When you find apparent flaws, you’ve got to be sensitive and keep track of those things, and keep an eye out for how they can be explained or how the theory can be changed to fit them. Those are often the great scientific contributions.”

Rule 8: Work on the Important Problems in Your Field

It is surprising but true that the average scientist spends almost all his time working on problems that he believes not to be important and not to be likely to lead to important results. By contrast, those seeking to do great work must ask: “What are the important problems of my field? What important problems am I working on?” Hamming again: “It’s that simple. If you want to do great work, you clearly must work on important problems. . . . I finally adopted what I called ‘Great Thoughts Time.’ When I went to lunch Friday noon, I would only discuss great thoughts after that. By great thoughts I mean ones like: ‘What will be the impact of computers on science and how can I change it?’”

Rule 9: Be Committed to Your Problem

Scientists who are not fully committed to their problem seldom produce first-class work. To a large extent, creativity comes out of the subconscious. If you are deeply

immersed in and committed to a topic, day after day, your subconscious has nothing to do but work on your problem. Hamming says it best: “So the way to manage yourself is that when you have a real important problem you don’t let anything else get the center of your attention—you keep your thoughts on the problem. Keep your subconscious starved so it has to work on *your* problem, so you can sleep peacefully and get the answer in the morning, free.”

Rule 10: Leave Your Door Open

Keeping the door to your office closed makes you more productive in the short term. But ten years later, somehow you may not quite know what problems are worth working on, and all the hard work you do will be “sort of tangential” in importance. He (or she) who leaves the door open gets all kinds of interruptions, but he (or she) also occasionally gets clues as to what the world is and what might be important. Again, Hamming deserves to be quoted verbatim: “There is a pretty good correlation between those who work with the doors open and those who ultimately do important things, although people who work with doors closed often work harder. Somehow they seem to work on slightly the wrong thing—not much, but enough that they miss fame.”

In our view, Rule 10 may be the key to getting the best research done because it will help you to obey Rules 1–9, and, most importantly, it will foster group creativity [9]. A discussion over lunch

with your colleagues is often worth much more than a trip to the library. However, when choosing your lunchmates (and, by implication, your institution), be on your toes. As Hamming says: “When you talk to other people, you want to get rid of those sound absorbers who are nice people but merely say ‘Oh yes,’ and to find those who will stimulate you right back.”

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Editorial

Ten Simple Rules for Graduate Students

Jenny Gu, Philip E. Bourne*

Choosing to go to graduate school is a major life decision. Whether you have already made that decision or are about to, now it is time to consider how best to be a successful graduate student. Here are some thoughts from someone who holds these memories fresh in her mind (JG) and from someone who has had a whole career to reflect back on the decisions made in graduate school, both good and bad (PEB). These thoughts taken together, from former student and mentor, represent experiences spanning some 25 or more years. For ease, these experiences are presented as ten simple rules, in approximate order of priority as defined by a number of graduate students we have consulted here in the US; but we hope the rules are more globally applicable, even though length, method of evaluation, and institutional structure of graduate education varies widely. These rules are intended as a companion to earlier editorials covering other areas of professional development [1–7].

Rule 1: Let Passion Be the Driving Force of Your Success

As with so many other things in life, your heart and then your head should dictate what thesis project makes sense to embark on. Doing your best work requires that you are passionate about what you are doing. Graduate school is an investment of up to a seven-year commitment, a significant chunk of your life. Use the time wisely. The educational system provides a variety of failsafe mechanisms depending on the part of the world where you study. Laboratory rotations and other forms of apprenticeship should not be overlooked, for they are opportunities to test the waters and measure your passion in a given subject area. It is also a chance to test your aptitude for research. Take advantage of it! Research is very different from simply taking courses. If you do not feel excited about doing research and the project selected, do not do it; reevaluate your career decisions.

Rule 2: Select the Right Mentor, Project, and Laboratory

Finding the right mentor can be hard since it is not always possible to know the kind of mentoring that is going to work best for you until you actually start doing research. Some of us like to work independently, others like significant feedback and supervision. Talk to other students in the laboratory and get their impressions of how the principle investigator's mentoring works for them. In a large laboratory, chances are you will get less direct mentoring from the principle investigator. In that case, other senior scientists in the laboratory become important. What mentoring are they likely to offer? Judge, as best you can, if the overall environment will work for you. A key element is the standing of your mentor in his or her scientific field. When you graduate, the laboratory you graduate from is going to play a role in determining what opportunities exist for your postdoctoral work, either in academia, industry, or other sectors. Your proposed mentor should be very enthusiastic about the project you discuss. If he or she is not, you have the wrong mentor and/or project. At the same time, beware that such enthusiasm, however senior the mentor, may be misplaced as far as your interests are concerned. Gauge the novelty of the research project and potential for high-quality publications by doing your own background check through reading previously published research and talking to other scientists in related areas. Also consider if the project can be reasonably completed in the allocated time for graduation. To propel your career, you want to come out of a higher degree as a recognized individual having made a significant scientific contribution. Thus, it is absolutely critical that you do take the time to find the project and mentor that is going to fulfill this goal.

Rule 3: Independent Thinking Is a Mark of a True Scientist

Regardless of your initial work habits and how much you depend on your

mentor (Rule 2), eventually you will have to be more independent than when you started graduate school. The earlier you start on that path to independence the better. Independence will play a critical part in your career as an innovative scientist. As much as possible define your own research project with a view to make a significant and unique scientific contribution.

Rule 4: Remember, Life Is All about Balance

Take the time to meet your own needs. Graduate school is highly demanding, both mentally and physically. Your health comes first, spend the time being healthy or else you might find yourself spending more time being sick. Hard work should be balanced with other activities that you enjoy and give you a break. These activities can often become important in your future scientific career. Collaborations sometimes start not because of a shared scientific interest initially, but because you share the same hobby or other interest.

Rule 5: Think Ahead and Develop Your Professional Career Early

There are two parts to this. The first part relates to professional development. Being a successful scientist is more involved than just doing good science. You need to be able to write good papers, submit compelling scholarship and grant applications, make powerful

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presentations, and communicate and collaborate with other researchers. The other Ten Simple Rules editorials are a start here [1–7], but you need to work on developing these skills at the same time as you work on your thesis. The second part involves using these emergent skills to figure out what to do with the higher postgraduate degree. Do not wait until you graduate to take the next step. Have a position and a fellowship, if possible, lined up ahead of time.

Rule 6: Remain Focused on Your Hypothesis While Avoiding Being Held Back

Formulation of the hypothesis is the first thing you'll learn in Science 101, and yet somehow it seems to get occasionally thrown out the window. When you find yourself lost in the details of your research, take a step back and remind yourself of the big picture. Reevaluate your hypothesis from time to time to see if it still makes sense, because you may find yourself needing a new one. Always keep this in mind in discussions with your mentor. As you have these discussions, remember you are cheap labor, and, if you are a good student, a source of success to your mentor. The temptation is that your mentor will want to keep you around as long as possible. Define the scope of your project early with your mentor and agree that this is what you will attempt to complete in order to receive the degree. A career awaits you beyond the laboratory of your graduate student days. Do not prolong moving on to new challenges.

Rule 7: Address Problems Earlier Rather Than Later

If graduate school wasn't quite what you thought it would be, be it scientifically or otherwise, find out what your options are to address the problem. Discuss these problems with your mentors. A good mentor is there not just to guide you scientifically, but also in your personal development. Remember, they have been there themselves and have likely seen similar issues with earlier students. Take time off to reflect on your future if this is

needed. A good mentor will understand that you come first.

Rule 8: Share Your Scientific Success with the World

Being recognized by your peers as someone who does good science is important both within your institution, nationally, and internationally. When opportunities arise to give seminars and presentations to other groups, take them. Before starting with a mentor, come to an agreement as to when and what meetings you can attend locally and globally. Scientific meetings are a fun and fruitful venue for exchange. Be sure to venture beyond the comfort zone of familiar faces, because it is important to meet other colleagues in your field. These people may become your future collaborators, friends, advocates, and employers.

Rule 9: Build Confidence and a Thick Skin

As you pave the road to scientific fame with Rule 8, expect your work to be criticized and scoffed at, for that is part of the scientific process of challenging new ideas. The best way to build self-confidence for these otherwise defensive moments is to be prepared and to present your work clearly with a confident display of your expansive knowledgebase of the relevant related work. Do not be intimidated by big names who question your work; counter knowledge with knowledge. Another reason to have a thick skin is that the path to success will not be without setbacks—setbacks such as experiments that fail, and experiments that succeed but do not yield a useful result causing you to have wasted significant time. Undergraduate training is usually much more structured and does not prepare you for such setbacks. Learn as much as you can from these situations both about the science and yourself and move on.

Rule 10: Help Select and Subsequently Engage Your Thesis Committee

This rule depends somewhat on how your institution is structured. Some

institutions do not convene a thesis committee until near the end of your work. For those institutions that require a thesis committee to be convened early, talk with your mentor and be involved in the selection process. The committee is there to work for you as secondary mentors. Consider people whose own research experience will be valuable to you or who have a reputation for ongoing mentoring in all areas of professional development. Make a point of talking to members of the committee from time to time and keep them abreast of what you are doing. On occasion, you and your primary mentor may have disagreements; committee members can be invaluable here. ■

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Ten Simple Rules for Aspiring Scientists in a Low-Income Country

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Being a scientist entails a common set of characteristics. Admiring nature and having concern for social issues; possessing a strong academic background, team work abilities, honesty, discipline, skepticism, communication skills, competitiveness, ability to accept and give criticism, and productive relationships are some of the most obvious traits that scientists should have. To be a scientist in a low-income country (LIC), however, requires a complementary set of qualities that are necessary to confront the drawbacks that work against the development of science. The failure of many young researchers to mature as professional scientists upon their return to their country from advanced training elsewhere, motivated us to propose these ten rules.

Rule 1: Understand Your Country

Most LIC scientists want to live in their home country. Nevertheless, you must be realistic and prepared to face rudimentary laboratories, power cuts, poor water supply, deficient libraries, slow Internet, and scarce or non-existent national funds for supporting research, hiring personnel, and providing maintenance or equipment. You must understand that science is a minor component of the cultural environment of an LIC and that, for most people and many politicians, science is a curiosity performed in high-income countries [1]. Within this adverse scenario, you should establish broad and strong links with your community and country. This involves becoming interested in historical, social, and political issues. LIC researchers have to enjoy the idiosyncrasies of their country, and cultivate the desire to contribute to the scientific development of their homeland and to the well-being of its people. Do not endorse deep doubts about the possibilities of performing research. It can be done—but not alone. Try to join efforts with other investigators facing the same problems. Learn how they sidetrack difficulties, and incorporate yourself into a research team. If you are not able to find a group that fits your specific interest, then procure a group of researchers who,

although investigating topics marginal to your own, are capable of understanding the relevance of your work. At the initial phases of your career, belonging to a creative scientific environment in which your knowledge and skills are appreciated is of major importance. Be part of a team before trying to lead one.

Rule 2: Focus on Your Scientific Work

Your formal education has finished, but your scientific career is just beginning. Research should be your main professional activity. Consider that you may be the country's only specialist in a particular topic, but keep in mind that science is global. You are a small fish in a big pond and part of an international community. Grow within this global context. Concentrate on your work, and do not pay attention to flattering comments. Above all, keep away from activities that distract you from scientific endeavor, such as excessive administrative duties, and too many committees. Limit the number of meetings and attend only the relevant ones. Even though you are well prepared, modestly declare yourself as “ignorant” in topics that may distract you, and fight against excessive lecturing. However, participate in graduate programs and seminars. This is the right environment for the promotion of academic knowledge and skills.

Rule 3: Be Wise When Selecting Your Research Topic

LICs face many problems that await creative solutions. Bizarre as it sounds, you can turn this into an advantage since these

same problems constitute excellent sources for research and offer comparative advantages. Try to choose a topic that is not directly pursued by many or strong international research teams. At the beginning of your career, you cannot compete with them and your efforts may be frustrated. Identify the potential bottlenecks. Remember that in LICs research time runs slower and that good science is not so much related to the subject as to the answers you extract from your investigations. Frequently, local models become universal once a coherent story is built around them. Become an expert and, simultaneously, broaden your knowledge in collateral areas that may open new possibilities.

Rule 4: Improve Your Communication Skills

English is the language of natural sciences, and you cannot avoid this fact. Consequently, you should be proficient in this language. The international scientific community is lenient about strong accents. However, the same community does not tolerate poor writing. Thus, writing skills are essential, since research begins with written proposals [2] and does not end until your results have been published [3]. You, more than native English speakers, must practice your oral presentations [4].

Rule 5: Collaborate Locally and Internationally

Collaboration is essential for the advancement of science. Although this holds true for any researcher in the world [5], it is crucial for LIC investigators. Identify local groups who share your scientific

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interest, have equipment, or perform activities or techniques that are useful for your research. Keep in touch with your former tutor and colleagues and explore new collaborations abroad. Do not be shy about requesting help, and offer something that attracts the attention of your counterparts. Attend international meetings and present your work. Research is, in a way, a trade market of ideas, methods, and goods. Travel and visit research institutions. If some experiments cannot be carried out in your country, arrange to perform them abroad, or convince people to do them for you. There are international funds available for this purpose.

Rule 6: Commit Yourself to the Education of Young Scientists

LIC researchers should participate in graduate training programs since this is the best way to build a strong scientific community. It is also a way to identify good young students and potential partners. Carefully choose the subjects for your students, pondering the possibilities of your research center, and be realistic about what they can achieve and the risks you are imposing on them. Upgrade your students' education by sending them abroad for seminars and for learning specific methodologies (<http://iscbsc.org/scs3/index.htm>). There are international fellowships for this purpose (<http://www.twas.org/>). Be strict but generous with your students and colleagues, and, whenever possible, share your facilities and knowledge. Do not be self-centered. Promoting the success of others is also a way to promote your own success.

Rule 7: Write Research Grants and Publish in International Journals

Scientific amateurism is common in LICs. Science is not a hobby but a professional activity that requires strong

commitment. Inform yourself about local and international granting agencies, and apply for money [2]. There are international agencies and programs that provide grant and travel funds for LIC investigators (e.g., TWAS, IFS, EU, NIH, etc.). Although funds are limited, they will help you to build your scientific career. Incorporate yourself into international consortia; they may find your ideas and resources interesting. If you do not have access to essential publications, send requests to authors, editors, or colleagues abroad. Avoid publishing your results in magazines or low-quality journals, and instead submit your work to international journals. Do not overestimate or underestimate your work, be realistic when choosing a suitable journal [3], and, above all, do not be overly frustrated when grants or papers are rejected; instead, use the experience as a source of learning. Even though some reviewers may undervalue research performed in LICs, most of them pay more attention to the results and ideas than to nationalities [6].

Rule 8: Develop Endurance When Confronting Difficulties

It is understandable that the limitations of performing research in LICs sometimes weaken your enthusiasm. Remain calm and try to identify the source of the problem; avoid complaining excessively in front of students, colleagues, or your partners abroad. A negative attitude is contagious, lowers your prestige, and has the tendency to attract unproductive people. Share your problems with other local scientists and confront them as a team. You should cultivate your abilities to find alternative solutions, as well as skills to improvise and to persuade people.

Rule 9: Educate Yourself as a Professional Scientist

To be a specialist in an LIC is not enough. Be aware that the scientific

community in an LIC is in short supply and lacks redundancy. In order to confront the drawbacks and deficiencies of the system, you must acquire a wide scientific knowledge, and become a well educated person in a broad sense. In addition to helping the quality of your research, this will give you the credentials to participate in political decisions related to science, to promote your ideas, and to spread scientific knowledge in your country. Acquaint yourself with local and international trends related to scientific performance and keep track of the major breakthroughs in science. Give talks and write about science whenever you consider it pertinent, but without diverting your attention too much from your main scientific duties.

Rule 10: Appreciate Being a Scientist

As most scientists from high income countries and from LICs know, we are prone to facing economic difficulties at the beginning of our careers. Generally, salaries for scientists are comparatively low. Nevertheless, in time scientists can achieve a satisfying income; furthermore, there are compensations, especially if you become a successful scientist. A sense of achievement and contribution to your community, prestige, travel, meeting interesting people, and consulting opportunities are some of them, but nothing is more rewarding than the intellectual stimulation of science itself. This was your original motivation; nourish it with more and better science.

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Ten Simple Rules for Organizing a Scientific Meeting

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Scientific meetings come in various flavors—from one-day focused workshops of 1–20 people to large-scale multiple-day meetings of 1,000 or more delegates, including keynotes, sessions, posters, social events, and so on. These ten rules are intended to provide insights into organizing meetings across the scale.

Scientific meetings are at the heart of a scientist's professional life since they provide an invaluable opportunity for learning, networking, and exploring new ideas. In addition, meetings should be enjoyable experiences that add exciting breaks to the usual routine in the laboratory. Being involved in organizing these meetings later in your career is a community responsibility. Being involved in the organization early in your career is a valuable learning experience [1]. First, it provides visibility and gets your name and face known in the community. Second, it is useful for developing essential skills in organization, management, team work, and financial responsibility, all of which are useful in your later career. Notwithstanding, it takes a lot of time, and agreeing to help organize a meeting should be considered in the context of your need to get your research done and so is also a lesson in time management. What follows are the experiences of graduate students in organizing scientific meetings with some editorial oversight from someone more senior (PEB) who has organized a number of major meetings over the years.

The International Society for Computational Biology (ISCB) Student Council [2] is an organization within the ISCB that caters to computational biologists early in their career. The ISCB Student Council provides activities and events to its members that facilitate their scientific development. From our experience in organizing the Student Council Symposium [3,4], a meeting that so far has been held within the context of the ISMB [5,6] and ECCB conferences, we have gained knowledge that is typically not part of an academic curriculum and which is embodied in the following ten rules.

Rule 1: The Science Is the Most Important Thing

Good science, above all else, defines a good meeting; logistics are important, but secondary. Get the right people there, namely the best in the field and those who will be the best, and the rest will take care of itself. When choosing a topic for your conference, map it to the needs of your target audience. Make sure that you have a sufficiently wide range of areas, without being too general. The greater the number of topics covered, the more likely people are to come, but the less time you will have to focus on particular subject matter. Emerging areas can attract greater interest; try to include them in your program as much as possible; let your audience decide the program through the papers they submit to the general call for papers. This can be done with broad and compelling topic areas such as “Emerging Trends in ...” or “New Developments in ...”.

Rule 2: Allow for Plenty of Planning Time

Planning time should range from nine months to more than a year ahead of the conference, depending on the size of your event. Allow plenty of time to select your meeting venue; to call for, review, and accept scientific submissions; to arrange for affordable/discounted hotel rooms; to book flights and other transportation options to the conference. Having outstanding keynote speakers at your event will also require you contact them months in advance—the bigger the name, the more time is required.

Rule 3: Study All Potential Financial Issues Affecting Your Event

Sponsors are usually your primary source of funds, next to the delegates' registration fees. To increase the chances of being sponsored by industry, write them a clear proposal stating how the money will be spent and what benefits they can expect to get in return. You may also want to reserve a few time slots for industry talks or demos as a way of attracting more sponsors, but be wary that the scientific flavor of the meeting is not impacted by blatant commercialism. Make sure you first approach the sponsors that match your interest topics the closest. If they say they are not interested this year, keep their contact information, as they might be able to sponsor you in future events. Approach them early rather than later in any case. The cost of your conference will be proportional to the capacity of the venue; therefore, a good estimation of the number of attendees will provide you with a good estimate of your costs. You will need to include meals and coffee breaks together with the actual cost of renting your venue. Be aware that audiovisual costs can be additional as well as venue staff—look out for hidden costs. Aside from venue-related costs, additional expenditures might include travel fellowships, publication costs for proceedings in a journal, and awards for outstanding contributors. All these issues will determine how much you need to charge your participants to attend. Map all this out on a spreadsheet and do the math. Allow for contingencies, such as currency fluctuations and world-changing

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events that will impact attendance. For large meetings, consider insurance against such events. Starting with a template that others have used for previous similar conferences can be a big help.

Rule 4: Choose the Right Date and Location

Your conference needs to be as far away as possible from established conferences and other related meetings. Alternatively, you may want to organize your event around a main conference, in the form of a satellite meeting or Special Interest Group (SIG). Teaming up with established conferences may increase the chances of attracting more people (especially if this is your first time) and also save you a great deal of administrative work. If you decide to do it on your own, you should consider how easy it is to travel to your chosen location, whether it has a strong local community in your field, and whether it has cultural or other tourist attractions. Inexpensive accommodation and airfares to your conference are always a plus.

Rule 5: Create a Balanced Agenda

A conference is a place for people wanting to share and exchange ideas. Having many well-known speakers will raise the demand for your event (and the cost) but that has to be balanced with enough time for presentation of submitted materials. A mix of senior scientists and junior scientists always works for the better. Young researchers may be more enthusiastic and inspiring for students, while top senior scientists will be able to present a more complete perspective of the field. Allow plenty of time for socializing, too; breaks, meals, and poster sessions are ideal occasions to meet potential collaborators and to foster networking among peers.

Rule 6: Carefully Select Your Key Helpers: the Organizing Committees

A single person will not have all the skills necessary to organize a large meeting, but the organizing committee collectively needs to have the required expertise. You might want to separate the areas of responsibilities between your aides depending on their interests and availability. Some potential responsibilities you might delegate are: 1) content and design of the Web site promoting the meeting; 2) promotion materials and marketing; 3) finance and fundraising; 4) paper submis-

sions and review; 5) posters; 6) keynotes; 7) local organization; 8) program and speakers; 9) awards. Your organizing committee should be large enough to handle all the above but not too large, avoiding free-loaders and communication issues. It is invaluable to have a local organizing committee since they know local institutions, speakers, companies, and tourist attractions. Local organizations may also help you with administrative tasks; for example, dealing with registration of attendees and finding suitable accommodations around the venue.

Rule 7: Have the Members of the Organizing Committees Communicate Regularly

It is good to have planning sessions by teleconference ahead of the meeting. As far as possible, everyone should be familiar with all aspects of the meeting organization. This collective wisdom will make it less likely that important issues are forgotten. The local organizers should convince everyone that the venue will work. Use these sessions to assign responsibilities ahead of the meeting. Tasks such as manning the registration tables, carrying microphones for attendees to ask questions, introducing sessions and speakers, checking presentations ahead of time, and having poster boards, materials to attach posters, etc., are easily overlooked. In short, good communication will lead to you covering all the little things so easily forgotten.

Good communication continues throughout the meeting. All organizers should be able to contact each other throughout the meeting via mobile phone and e-mail. Distribute to all organizers the names and contact information of caterers, building managers, administrative personnel, technicians, and the main conference organizer if you are having your event as part of another conference. Onsite changes that incur additional costs, however, should require the approval of a single, key organizer rather than all organizers operating independently of one another. This will ensure there are no financial surprises in the end. It is also important that you have a designated meeting point where someone from the organizing committee is going to be available at all times to help with problems.

Rule 8: Prepare for Emergencies

Attendees need to be aware of all emergency procedures in terms of evacuation, etc. This should be discussed with

the venue managers. All attendees should be reachable as far as possible during the conference. If an attendee has an emergency at home, his or her family should be able to reach them through the conference desk—mobile phones are not perfect after all.

Rule 9: Wrap Up the Conference Properly

At the end of the conference, you should give credit to everyone who helped to make the event a success. If you have awards to present, this is the right time for the awards ceremony. Dedicate some time to thank your speakers and sponsors as well as everyone involved in the organization of the conference. Also collect feedback about the event from the delegates through questionnaires. This evaluation will help you to understand the strengths and weaknesses of your conference and give you the opportunity to improve possible future events. Have a party or some other event for all those organizing the conference.

Rule 10: Make the Impact of Your Conference Last

Published proceedings are the best way to make the results of your conference last. Negotiate with journals far in advance of the conference to publish the proceedings. Make those proceedings as widely accessible as possible. Upload photos and videos of the event to the conference Web site and post the names of presenters who have received awards or travel fellowships. It is also a good idea to link the results of your evaluation to the Web site. Send one last e-mail to all delegates, including a summary of the activities since the conference and thanking them for their participation. This is particularly important if you are considering holding the conference again in future years, in which case include some information on your plans for the next event.

As always, we welcome your comments and experiences that you think would enrich these ten rules so that they might be useful to others. The comment feature now supported by this journal makes it easy to do this.

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Ten Simple Rules To Combine Teaching and Research

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The late Lindley J. Stiles famously made himself an advocate for teaching during his professorship at the University of Colorado: “If a better world is your aim, all must agree: The best should teach” (<http://thebestshouldteach.org/>). In fact, dispensing high-quality teaching and professional education is the primary goal of any university [1]. Thus, for most faculty positions in academia, teaching is a significant requirement of the job. Yet, the higher education programs offered to Ph.D. students do not necessarily incorporate any form of teaching exposure. We offer 10 simple rules that should help you to get prepared for the challenge of teaching while keeping some composure.

Rule 1: Strictly Budget Your Time for Teaching and for Doing Research

This rule may seem straightforward, but respecting it actually requires more discipline and skill than it first appears to. The key is to set aside time for both teaching and research from the beginning, with a well-marked separation (e.g., mornings will be devoted to course preparation, afternoons to experiments and manuscript writing). Firmly stick to this agenda, particularly if this is your first time teaching. Failure to do so would eventually affect the quality of your teaching or the progress of your research (or both). Over time, you will become more skilled at jumping from one commitment to the other, and therefore allowing the boundaries to fluctuate somewhat. Avoid underestimating the time necessary to fulfill teaching-related obligations (e.g., office hours, test preparation, grading, etc.) by consulting with your colleagues.

Rule 2: Set Specific Teaching and Research Goals

In order not to have one occupation overpower the other one—which would transgress Rule #1—it is a good idea to decide on specific aims for each enterprise. Compile a list of reasonable but specific long-term goals (for the month or the semester) and short-term ones (for the week) for both your teaching (e.g., finish Chapter 3 by Nov. 1; this week propose a discussion

to engage students to brainstorm about the risks of GMOs) and your research (e.g., finish experiments for this project and start writing before Easter; this week do the control for my primer binding assay). Make sure you achieve them. If you don’t—this is likely to happen at first—ask yourself how legitimate your reason is. Then review and adjust the goals accordingly.

Rule 3: “Don’t Reinvent the Wheel”

We borrowed the title for this rule from excellent suggestions on *How To Prepare New Courses While Keeping Your Sanity* [2]. Most likely, you will not be the first one ever to teach a particular topic. So get in touch with the colleagues in your department who have taught the class you are going to teach, or who teach similar topics. You can also use your network and contact former colleagues or friends at other institutions. They will usually be happy to share their course material, and along the way you might also glean precious tips from their teaching experience (e.g., a list of do’s and don’ts on how to approach a notoriously difficult topic). You will also learn a lot from sitting in one of their classes and watching how they handle their topic and their students. Here are more examples of precious time-savers:

- (1) Choose a textbook that is accompanied by rich online resources such as annotated figures, pre-made PowerPoint slides, animations, and videos. Students will thank you for showing movies, for example, as they often are a better option to break down complex mechanisms or sequences of events into distinct steps.

- (2) Administer a Web site for your course. Many universities and some textbooks now offer you the possibility of hosting a Web site with course-related materials, including automatically graded assessments. See, for example, the CULearn suite used at the University of Colorado (<http://www.colorado.edu/its/culearn/>), or more general automatic grading tools presented at <http://ctl.stanford.edu/Tomprof/postings/227.html>.
- (3) Gather a solid team of motivated teaching or learning assistants, who will both serve as an intermediary between you and your students and help you grade. In short, don’t be afraid to ask for help!

Rule 4: Don’t Try To Explain Everything

Class time should be spent guiding students to create their own explanation of the material and to develop cognitive abilities that will help them become critical thinkers. In other words, you don’t want to present all aspects related to a certain topic or to lay out all the explanations for them. Thus, an effective way to teach is to get students to learn by transformative learning: beyond memorizing and comprehending basic concepts, they will learn to reflect on what they learn and how they learn it (see, for example, http://en.wikipedia.org/wiki/Transformative_learning and references within). Such teaching practices require that a significant part of the learning process happens outside the classroom, through reading assignments, homework, writing essays, etc. So make sure you budget time to organize these, as specified

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in Rule #2. Remember that in the end this will be a win-win situation: you will save time by not having to fit everything into your class time, and students will learn how to find answers through their own thinking.

Rule 5: “Be Shameless in Bringing Your Research Interests into Your Teaching”

This is yet another great time-saver, and this rule title is actually from *Confessions about Stress and Time: Thoughts for Faculty* (available at <http://www.colorado.edu/ftp/publications/confessions.html>). Students want to know how what you teach relates to the world around them. They also like to know what is happening in science right now, so this is where you can feed in some of your research interests (for some examples of how researchers around the world have been bringing their research into the classroom, refer to the special section of the July 6, 2007, issue of the magazine *Science* entitled *The World of Undergraduate Education* [3]). Students will welcome such connections, especially in an introductory course or in a course for non-majors. Additionally, they will feel the passion that makes you love being a scientist. On your end, you might find that preparing course materials will be easier (because you are already a master of that topic), and you might learn to be more comfortable at presenting your research in layman’s terms.

Rule 6: Get the Most in Career Advancement from Bringing Your Research into Your Teaching

As a sort of followup to Rule #5, presenting your research in class could bring you a solid return on your investment. For example, teaching gives you exposure; talking about your research may help you recruit motivated students in your lab, which will help you advance your research, possibly by taking it in original directions. In parallel, you could also use your research to design a novel course and possibly evaluate student learning in a fashion that would make for a publication in a science education journal. Another option would be to write or edit a book, or to contribute a

chapter in someone else’s book that you would eventually give as a reading assignment in your class. Conversely, there is wisdom in crowds. Consider having students review aspects of your research that fit the course and get feedback. You will be surprised at what useful information can come from students critiquing a new manuscript or proposing new experiments.

Rule 7: Compromise, Compromise, Compromise

A significant part of the compromise once you accept a joint research/teaching commitment is to realize that your list of “things that in principle you would like to do but won’t have time to do” will get longer. Maybe you would like to personally respond to all the students who e-mail you about any problem they may have, but, realistically, such things can’t happen. Instead, a solution would be to send some general feedback in answer to the common queries and to write occasional brief personal responses. As you get more skilled at combining research and teaching, you will be able to progressively bring back activities such as scanning the most recent scientific literature and attending seminars and lectures more often. But remember to accept that no matter how skilled you are at budgeting your time for teaching and research, you will still face the conflicting demands of both, and you will have to keep compromising. In the end, compromising will sometimes imply learning to say no when pondering about taking on a novel and exciting assignment that would unequivocally conflict with your current research/teaching agenda.

Rule 8: Balance Administrative Duties with Your Teaching and Research Workload

Your responsibility as a teacher and as a researcher is to be as productive as you can be in these two areas, at the same time. This is what your colleagues and the faculty board will expect from you when evaluating you for tenure, for example. Doing service within your community (for example by sitting on committee meetings, or by being part of a local scientific club) counts as well, but not as much. In consequence, turning down yet another

offer to organize a series of seminars, or to edit the newsletter of your department, is legitimate if it cuts into your productivity. Similarly, keep your ability to career advance in mind when considering taking on another teaching assignment.

Rule 9: Start Teaching Early in Your Career

This will be the best way to get exposed to some of the difficulties mentioned in the other Rules sooner rather than later. You can see this as an opportunity to learn how to add on various responsibilities in a gradual rather than an immediate manner (e.g., when “jumping” from a post-doc to a faculty position at a university). Many options are available to teach at the graduate level (e.g., by becoming a teaching/learning assistant), as well as at the post-graduate level (e.g., by teaching part-time on campus or at a local school while doing your post-doc). You may need to be proactive about looking for such opportunities, but an increasing number of universities and institutions are developing programs that formally offer teaching experience to graduate students and post-docs [4,5].

Rule 10: Budget Time for Yourself, Too

A lot of stress can build up from a constant shuttle between teaching demands and research occupations. In order to be able to evacuate some of that tension, it is a good idea to hide some time for yourself that you will spend with your family, or to do your hobby, to exercise, to travel, etc. An unfulfilling personal life is incompatible with successful teaching and research careers. Consequently, don’t forget to spend some energy learning how to balance both areas.

Finally, keep in mind that your experience can make for a valuable contribution to the scientific community, for example, in the form of a report on your efforts in science education, or by posting comments to this Editorial!

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Ten Simple Rules for Choosing between Industry and Academia

David B. Searls*

One of the most significant decisions we face as scientists comes at the end of our formal education. Choosing between industry and academia is easy for some, incredibly fraught for others. The author has made two complete cycles between these career destinations, including on the one hand 16 years in academia, as grad student (twice, in biology and in computer science), post-doc, and faculty, and on the other hand 19 years in two different industries (computer and pharmaceutical). The following rules reflect that experience, and my own opinions.

Rule 1: Assess Your Qualifications

If you are a freshly minted Ph.D., you know that you will need a good post-doc or two before you can be seriously considered for a junior faculty position. If you're impatient, you might be thinking of industry as a way to short-circuit that long haul. You should be aware that companies will strongly consider your post-doctoral experience (or lack thereof) in determining your starting position and salary. While you may not relish extending your indentured servitude in academia, any disadvantage, financial and otherwise, can quickly be made up in the early years of your career in industry. In other words, trying to get off the mark quickly is not necessarily a good reason to choose industry over academia.

On the other hand, you may have completed an undergraduate or Master's program with a view to going to industry all along, with never a thought of an academic career. You should still consider the point of the previous paragraph. While abbreviated "practical" bioinformatics training programs can be excellent, a Ph.D. is a significant advantage in all but the most IT-oriented positions in industry, at least at the outset. This is not to discourage anyone from embarking on a fast-track-to-industry program if their heart is in it, but be aware that the further you climb the educational ladder, the higher and faster you can start when you step across to the business ladder, and the better you will compete for a job in the first place. The days are long past when

bioinformaticists were in such short supply that any qualification would do.

If you are an old hand and have already notched up a post-doc or two, take stock of your star power. This unspoken but universally understood metric encompasses such factors as whom you've trained with, where you've published (and how much), and what recent results of yours are on everyone's lips. If you are fortunate enough to have significant capital in this department, then the world may be your oyster, but you still need to consider where you will get the greatest leverage. While your stardom may be less taken for granted in industry, my feeling is that academia is a better near-term choice in such circumstances. Consider that it was in academia that you achieved the success you own thus far, so you obviously "get it." The simple fact is that academia is rather more of a star system (as in Hollywood) than is industry.

Finally, if you count among your qualifications a stint in industry already, as an intern or perhaps as part of a collaboration, you will not only be in a better position to compete for a permanent job, but you will be much better prepared to make the decision facing you. Stated another way, if you are seriously considering industry as a career path, you should probably have already taken advantage of the many opportunities out there to dip your toes in the water.

Rule 2: Assess Your Needs

In taking stock of your needs, and perhaps those of your family, a decent living is generally at or near the top of the list. Salaries are still higher in industry, though the gap is not nearly so wide as it once was. If

you need a quick infusion of cash, companies may offer signing bonuses, though again these were more common when bioinformatics was a rarer commodity.

Industry offers forms of compensation unavailable in academia, and you will need to consider how to value them relative to your present and future needs. Despite recent bad press, bonus systems are often part of the equation, and depending on your entry point they may constitute a significant percentage of total compensation. There is a tendency among academics to discount bonus programs in their comparison shopping, sometimes to zero, and this is a mistake. Bonuses are considered core aspects of compensation in most companies, and though they always have a performance-based multiplier, the base levels have historically been fairly dependable. That said, these are tough times in industry, and there are no guarantees. Your best strategy is to understand the reward system thoroughly, ask for historical data, and avoid comparing only base salaries unless you are extraordinarily risk-averse.

Share options are another matter. While in the past these were very attractive, and fruitful in practice, most industry types will tell you frankly that any options they've received in the past decade are deep underwater and a deep disappointment. Many consider pharma shares (and therefore options) to be a bargain at the moment, but that's between you and your financial adviser to assess. In any case, it is not a short-term consideration, since options typically take several years to vest.

If you are looking at biotech, however, share options and similar ownership schemes need to be a key consideration,

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since these are a major rationale for assuming risk—more on that below.

Finally, you may have more specific needs to consider, such as a spouse also in need of a job. The two-body problem has always been tougher in academia than in industry, and probably always will be. If you are both academics, note that industry often has good contacts with local universities, and can facilitate interviews. Being a star certainly helps, so don't be afraid to negotiate. In fact, a general rule of thumb is that it never hurts to make your specific needs known, within reason. Academia will try to accommodate them as a community, while on the other hand business (particularly large, diversified companies) may have resources to address them that you wouldn't have expected. Nobody wants to hear a peremptory demand, but if a company wants you, be sure to let them know anything that might offer them a way to attract you.

Rule 3: Assess Your Desires

There are needs, and then there are desires. Do you want riches? Fame? A life at the frontiers of knowledge? The hurly-burly of the business world? How do you really feel about teaching, publishing, managing, interacting, traveling, negotiating, collaborating, presenting, reporting, reviewing, fundraising, deal-making, and on and on? Though it may seem obvious, this is a good time to decide what really drives you.

First, the obvious. Do you want to teach? If lecturing is in your blood, your decision is made, although if a smattering will suffice you may have the option from within industry of an adjunct academic appointment. (By the same token, if you are not so enchanted with lecturing, grading, tutoring, etc., there are often options for research track professorships that minimize teaching duties.) Do you want to publish? While it will always be “publish or perish” in academia, it is certainly possible to grow your CV in industry, and it can even enhance your career, depending on the company. However, it might be largely on your own time, and you will likely encounter restrictions in proprietary matters, though in practice you can generally find ways to work within them. Ask about publication at the interview, both policies and attitudes, and watch out for any defensiveness.

An important question, surprisingly often overlooked, is how you want to actually spend your time, day by day and hour by hour. In academia, you will immediately be plugged into hands-on

science, and your drivers will be to start out on your career by getting results, publishing, networking, and building your reputation with a view to impressing your tenure committee. A career in industry may put more of an early emphasis on your organizational aptitude, people skills, powers of persuasion, ability to strategize and execute to plan, etc.; in terms of growing your reputation, your audience will be the rather narrower community of your immediate management. A somewhat more cynical view would be that in business you will spend seemingly endless hours in meetings and writing plans and reports, while in academia you will spend all that time and more in grantsmanship—in this regard, you must pick your poison.

Finally there is the elephant-in-the-room question: Do you want to make money, or to help people? This is, of course, a false dichotomy, but many people consciously or unconsciously frame the decision in just this way, and you had best deal with it. Try thinking of it not so much in terms of the profit motives of the respective institutions, but in terms of the people with whom you would spend your career. You should have encountered a good sampling of scientists from industry during meetings, internships, collaborations, interviews, etc. (or in any case you should certainly try to do so before making judgments). If you are left in any doubt as to their ethics or sincere desire to relieve human suffering as efficiently as possible, or if you feel these are somehow trumped by the corporate milieu, then by all means choose academia—but only after applying analogous tests to the academics you already know well. In my experience, business doesn't have a monopoly on greed, nor are humanitarian impulses restricted to academia. That said, in the final analysis you must be comfortable with your role in the social order and not finesse the question.

Rule 4: Assess Your Personality

Not surprisingly, some personality types are better-suited to one environment or the other. Raw ambition can be viewed as unseemly in either case, but there is more latitude for it in industry, and greater likelihood of being recognized and rewarded sooner if you are “on the go.” In fact, one of the clearest differences between academia and industry are their respective time constants. Although the pace of academia may have quickened of late, it is still stately by comparison with industry, and much more scheduled (so many years to tenure, so many months to

a funding decision, etc.). If you are impatient, industry offers relatively fast-paced decision-making and constant change. If you thrive more under structured expectations, academia would be better for you, for although industry has all the trappings of long-range strategies and career planning, the highly reactive environment means these are more honored in the breach. For one thing, reorganizations are common, and in the extreme case mergers (I have experienced two) can reset everything, for good or ill, and devour many months.

This is not to say that all is chaos—industry certainly favors a goal-directed personality, but with plenty of flexibility. On the other hand, flexibility is more the hallmark of academic research, where you will have the opportunity to follow wherever the science leads, once you are running your own shop. In industry, the flexibility is more of the conforming sort, since you won't be able to investigate every promising lead and change your research direction at will. In academia, diverging from the Specific Aims of a grant may be a problem when the time comes to renew, but the risk is yours, as is the reward. In industry, you can make the case for a new program of research, but the decision is management's and will be guided by business considerations. The “lone wolf” or “one-person band” may be increasingly rare in academia in an age of collaboration, but it is unheard of in industry, where being able to work in teams with specialized division of labor is essential. It should be apparent, as well, that mavericks and quirky personalities tend to do better in academia.

The pecking order in industry is deeper and more pyramidal than in academia, and you might end up languishing in a pay grade (or feel like you are), but there are usually plenty of opportunities for lateral moves and a variety of experiences—not to mention that it's easier to switch companies than colleges. In industry, one does need to be able to thrive in a hierarchy; you will always answer to someone, though the degree to which you are monitored will vary. By the same token, if your personality is such that climbing a management ladder and assuming steadily greater responsibility suits you, industry is built for that, and plenty of management training is on offer in larger companies. Learning to manage is much more hit-or-miss in academia; opportunities to lead large organizations are rare (and to manage them actively rather than by consensus, rarer still).

If your personality type is that of a risk-taker, biotech and/or startups may fit you to a tee. These are the wild and woolly end of the industry spectrum, and the risks and rewards are well-known. You will work longer hours than in large pharma, and maybe even more than in academia. You will most likely share more in ownership, and learn entrepreneurial skills that will serve you well, once the bug has bitten. Bear in mind the very common pattern of faculty spinning off startups or otherwise participating in boards and the like, not to mention staking out intellectual property (shared with their university); thus, you may well be able to scratch this itch from the vantage of academia as well.

A final word about politics. Whether you are an enthusiastically political animal, or abhor this aspect of the human condition, you will encounter plenty of politics in both academia and industry. The flavors differ, to be sure. As a student you doubtless heard the clichés about tedious academic committees and underhanded deans, but you have probably had more exposure to the realities behind those stories than the corresponding ones about the dog-eat-dog corporate world. Company politics, I would hazard to say, are more transparent—the maneuvering more open and the motives more apparent. The results are often more life-altering, unbuffered by tenure and academic convention. Again, it is a matter of taste, but in my opinion the differences are overblown, for the simple reason that people are the same everywhere, in both environments governed by an underlying sense of fair play, but also occasional opportunism.

Rule 5: Consider the Alternatives

As I've suggested, the choice you face is far more fine-grained than simply that between industry and academia. Industry is a spectrum, from large pharma to mature biotech to startup. By the same token, the academic side has at one extreme the research powerhouses, where you will be judged by volume of grants, and at the other the teaching institutions, which may not even have graduate departments. Unless you are very sure of yourself, you'd be well-advised to consider the full range, given the competition you may face.

Also, don't neglect other careers that may value your training. If you love the language, consider science journalism, either writing or editing—*Science* and *Nature* have large staffs, and you will often encounter them and representatives of

other journals at the same scientific meetings you attend. The same is true of government agencies such as the NIH, NSA, DOE, and so forth, where grants administration is very actively tied to research trends and can be an entrée into the world of science policy. There are many more such positions when foundations, interest groups, and other private funding bodies are included. If you have a knack for business, many management consulting firms have scientific and technical consulting arms that value Ph.D.s and offer intensive training opportunities, and, though it may not be attractive at the moment, a career as a financial analyst specializing in biotech is yet another possibility.

Rule 6: Consider the Timing

The current business environment cannot help but be among your considerations. Pharma has certainly been contributing to the unemployment rolls of late. Corporate strategies, which used to be very similar across the sector, have started to diverge, so that some companies are divesting bioinformatics at the same time that others are hiring computational types disproportionately as they place more of an emphasis on mathematical modeling, systems approaches, pharmacogenomics, drug repurposing, and the like. Overall, though, the industry trend has been to shrink R&D, and this may well continue through a round of consolidation, with several mega-mergers now under way. As noted above, mergers are times of upheaval, carrying both risk and opportunity, and usually a period in limbo as well. At the same time, it is worth bearing in mind that a corollary of downsizing is outsourcing, so that there may be new opportunities for startups and even individual consultants.

For much of the last decade, academia has also been in the doldrums, as NIH budgets have effectively contracted. As I write this, things are definitely looking up, with prospects for renewed funding of science and even near-term benefits to the NIH and NSA from the Obama stimulus package. Whether universities will respond proportionately with faculty hiring, given the losses in their endowment funds and cutbacks in salaries and discretionary spending, remains to be seen. There is a lot of slack to be taken up, and in particular a backlog of meritorious grant applications that are now being reconsidered. Nevertheless, on balance, an academic career has to be somewhat more promising today than a year ago, and a

career in pharma rather less so, in the opinion of the author.

Rule 7: Plan for the Long Term

Having noted the current situation in Rule 6, it's important also to say that a career decision should be made with the long haul in mind. The business cycle will eventually reverse itself, and while the business model may need to change irrevocably, the aging population alone dictates that healthcare will be an increasing global priority. Likewise, history shows that growth in government funding for science waxes and wanes, with a time constant somewhat longer than a decade. Trying to optimize a career decision based on current conditions is a bit like trying to time the stock market—you are sure to be overtaken by events.

One approach is to choose some reasonably long time frame, perhaps a decade, and ask yourself whether you'd be content to have lived through the average ups and downs you'd experience in a given job over that period. In academia, that would include a tenure decision (rate your chances), a lot of grant applications with mixed success at best, and maybe some great students and really significant scientific contributions. In pharma or large biotech, it would encompass a couple of promotions, your own group and maybe a department, at least one merger or other big disruption, and several rounds of layoffs. In small business, it might include a failed startup (or two, or three), an IPO if you're lucky, and a lucrative exit strategy or long-term growth if you're really lucky.

If you game these scenarios with various probabilities, and use your imagination, it just might become clear which ones you have no stomach for, and which ones really hold your interest.

Rule 8: Keep Your Options Open

Job-hopping is much more prevalent now than in days of yore, and you should consider this in your scenarios. In industry, there is little stigma attached to changing employers, and if you can tolerate the relocation and/or want to see the world, it is a more or less standard way to advance your career by larger-than-usual increments. This stratagem is far from unknown in academia, but perhaps a bit trickier to execute, though of course it is de rigueur if you fail to get tenure.

Of greater interest is the question of moving between academia and industry. From the former to the latter is fairly easy, but the reverse is not as common, for a variety of reasons. Superstar academics in

relevant areas are in great demand in industry, to which they are often exposed through consulting or scientific advisory boards. There are multiple examples of senior academics taking over major R&D organizations in industry, sometimes orders of magnitude larger than anything they managed in academia, and you might even consider this well-trod path as a career goal from the outset.

It is not impossible to return to academia from industry, particularly if you were already quite prominent when you left, but if you start your career in industry you may be at a disadvantage unless you go to great lengths to maintain an academic-style publication record and CV. Important exceptions would be if the work that you did in industry was particularly novel and/or high-profile, or if your business experience is valued in the post you seek. Examples of the latter might be faculty positions with a prominent management component (centers, institutes, core facilities, and the like), or an interface role back to industry, or perhaps a joint business school appointment.

Rule 9: Be Analytic

Approach the decision with the analytic skills you've learned to apply to scientific questions. Gather data from all available sources and organize it systematically. When you interview, don't just impress, but get impressions; record everything down to your gut feelings. Do some bibliometric or even social network analyses of your potential colleagues. Check the industry newsletters and blogs, albeit with a grain of salt, to get a sense of the mood around R&D units (not to be confused with manufacturing, sales and marketing, or other divisions, which may have completely different cultures within the same company).

You might even try out some decision theoretic methodologies, such as decision matrices and Bayesian decision trees, or run simulations on the scenarios of Rule 7. I recommend taking a look at expected utility theory and prospect theory, for an interesting quantitative excursion. But honestly, these suggestions are just a more sophisticated informatics version of the

classic advice to "make a list of pros and cons," which always makes one feel a little more in control.

Rule 10: Be Honest with Yourself

Another homily: Now, if ever, is the time to be honest with yourself. Take a hard look at your qualifications, with as much objectivity as you can muster, and use these rules to decide where you would be best-suited and positioned for success. But even more importantly, deal with your emotional responses to industry and academia. If something is nagging at you, tease it out into the open, and try to decide if it is well-founded or not; if you can't decide, then you have to acknowledge it, and realize that it may not go away in the future either.

Finally, try to keep some perspective. Your career choice is important, but not irrevocable, and there are more consequential things in life. Don't let the decision process ruin what should be an exciting time for you.

Editorial

Ten Simple Rules for Chairing a Scientific Session

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Chairing a session at a scientific conference is a thankless task. If you get it right, no one is likely to notice. But there are many ways to get it wrong and a little preparation goes a long way to making the session a success. Here are a few pointers that we have picked up over the years.

Rule 1: Don't Let Things Overtake

Probably the main role of the session chair is to keep the meeting running on time. Time is a strange and elastic concept when people are under pressure. Some speakers will talk much faster than normal and finish a talk in half the expected time. Others will ramble on without knowing that time is running out and they have only just finished their introduction. Timing is important to ensure that a meeting runs smoothly. Delegates should leave the session at just the right time so that lunches are still fresh, bars still open, etc. Timing is particularly acute if there are multiple parallel sessions and delegates would want to switch between talks in different sessions.

Rule 2: Let Your Speakers Know the Rules

A session will run more smoothly if you let all the speakers know how you plan to run your session. This could be done by e-mail before the event or you might want to gather up the speakers just before the session. Reminding them how much time they have to speak, how much time to allow for questions, and how you will let them know time is up will stop confusion later on. Beyond the rules, encourage speakers to review what others in the session will say. The less redundancy, the better the session will be for everyone, including the chair.

Rule 3: Be Prepared to Give a Short Introduction

Be prepared to give a short introduction to the session, and, of course, introduce yourself as well. Be sure to review the abstracts of the talks and then give a succinct summary of what will be presented.

It is your job to excite people at the session and have them stay in the auditorium. Regarding the speakers, introduce each one before they begin, providing their background and highlighting their major accomplishments. Speakers love to be properly introduced and the audience likes to feel they know the person speaking. But for the sake of both the timing of the session and your speakers, do keep it brief. Are you expected to give any housekeeping messages or to remind people to switch off their phones? Allow time for that if so.

Rule 4: Write Down the Actual Start Times of the Speakers

If you don't know what time a speaker started, it is difficult to know when to ask them to stop. So always write down the start and finish times of speakers throughout the session.

Rule 5: Do Have a Watch

It sounds obvious, but it is very difficult to chair a session if you don't have a watch and don't know the time. Yes, one of us has done this! It is embarrassing to have to ask your neighbor for a watch. Actually, it is probably best to have two watches, just in case.

Rule 6: Communicate How Much Time is Left to the Speaker

Letting the speaker know their time is up is crucial in keeping time. A simple sign held up at the right time is usually fine. Have one saying, "5 minutes to go" and another saying "time is up". Beyond that time, standing up on the stage is a good sign that the speaker should wrap up.

Rule 7: Don't Be Afraid to Move on Without Questions

A good scientific session is characterized by a lively question and answer session. In fact, some speakers believe it is their right to expect to answer questions even after their allotted time is up. If you are running over time, you should not be afraid to move on to the next talk without questions. You will be more confident in enforcing this principle if you have warned the speaker beforehand that running over will require foregoing taking questions at that time. You can stay on schedule by diplomatically saying that the speaker will be happy to take questions at the break.

Rule 8: Get to the Venue Early and Be Audiovisually Aware

Make sure to know where everything is, like pointers, microphones, projectors, and computers and who to turn to if it all goes wrong. It is worth checking that all these things work so that you can swiftly fix them yourself. Knowing ahead of time any unusual requests from speakers to show movies and sound clips requiring special attention. Be sure the venue supports the needs of speakers. If not, let them know before they get to the venue. If each speaker is expected to load their presentation on a single computer associated with the podium, allow time for that and have the speaker run through their slides to be sure everything is working properly.

Rule 9: Prepare Some Questions in Advance

It can take an audience a few seconds to digest the contents of a talk and think of questions. So it is always good to have one

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or two ready to ask. These can be prepared beforehand from the abstracts and supplemented from ones that occur to you during the talk. This is a very good reason for paying attention during the talk. Also, it is worth thinking of one or two general purpose questions such as “What do you plan to do next?”

Rule 10: Keep Control of the Question and Answer Sessions

It is difficult for the session chair to keep things on time if the speaker is in control of taking questions. Make sure you are the one who selects the next questioner. Also, be prepared to step in if the speaker and

questioner are getting into a long-winded, technical discussion.

Hopefully with a bit of preparation and a little luck, you will get through the ordeal of chairing a scientific session unscathed. And remember, if no one thanks you, you have probably done an excellent job.