PLoS COMPUTATIONAL BIOLOGY

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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PLoS COMPUTATIONAL BIOLOGY

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. Revaluate 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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Editorial

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 tasks 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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Editorial

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 submissions 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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Editorial

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/ftep/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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Editorial

Ten Simple Rules for Choosing between Industry and Academia

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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 plunged 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, biotechs and/or startups may fit you to a tee. These are the wild and wooly 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 Overrun

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.

Editorial

Ten Simple Rules for Organizing a Virtual Conference—Anywhere

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The *First African Virtual Conference on Bioinformatics 2009* (AFBIX09) [1], organized by the Bioinformatics Organization [2] and the International Society for Computational Biology Student Council's Regional Student Groups of Africa and Morocco (ISCBSC RSG-Africa and RSG-Morocco) [3] received support from the African Society for Bioinformatics and Computational Biology (ASBCB) [4]. The aim was to provide students and scientists in the bioinformatics and computational biology fields a chance to network through a unique platform conceptualized as "hubs." These hubs then gave participants the opportunity to foster both physical and virtual interactions as well as develop collaborations, irrespective of geographical location.

Virtual conferencing may prove to be an effective low-cost strategy for conveying bioinformatics and computational biology education to African scientists who otherwise would be deprived of the opportunity. Unlike conventional conferences, virtual conferencing permits the involvement of a greater number of participants who would otherwise be unable to participate in events of this breadth owing to (1) limited travel fellowships, if any; (2) lack of time to travel to distant conference locations; and (3) insufficient accommodation and subsistence funds. These factors apply in general to the post-/undergraduate student community and especially to the target audiences that reside in developing countries. Minimizing the requirement to travel also means that the availability of invited speakers is greatly increased, improving the chances of attracting highly relevant and high-impact presenters.

Through the use of video conferencing software, virtual conferences are able to provide an accessible and cost-effective alternative to real time conferences while retaining the key benefits presented by an on-site conference, such as learning opportunities, sharing of ideas, and networking. The use of inexpensive "commodity off-the-shelf" (COTS) technologies permit anyone with an Internet connection, Web cam, and headset to give and/or attend a presentation. According to Andrew Sage, Cisco Systems' vice president for marketing, virtual conferences "can live on long after the physical booths have been torn down," while content continues to be viewed in a dedicated virtual environment by many people, even after the conclusion of the event [5].

At the Fall Joint Computer Conference on December 9, 1968, Douglas Engelbart presented, among other innovations, a virtual conferencing system that utilized the broadcast of computer monitor video as well as presenter audio and video [6]. This "expensive approach" has involved traditional video conferencing and technologies such as the Access Grid [7], which have been viable options for the most affluent regions of the world, but the approaches mentioned here are broad enough to be used in both developed and undeveloped environments.

The conference was set up as a series of virtual hubs defined as a group of ten or more persons in one location. Each hub consisted of a computer attached to a Web cam and speakers with a stable Internet connection. The hub activities and the interaction with other hubs were coordinated by persons within the locality.

Speakers within faculty and industry were identified on the basis of their expertise or involvement and relevance to the research topics covered by the virtual conference. There were a total of 16 speakers and out of these, four were keynotes divided between 2 days and four sessions. In addition, there were five invited speakers and three oral presentations selected from 12 submitted abstracts. The rest of the abstracts were presented as posters during break sessions. There were tutorials, relevant discussions from senior faculties, as well as welcome and closing statements from AFBIX09 organizers.

The conference was 19 hours long and was held over 2 days. The first day consisted

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of 8 hours, tailored to accommodate time zone differences between each of the participating hubs. This was inclusive of 100 minutes of break time divided between two 20-minute coffee sessions concurrently spent on poster presentations, with an hour on a lunch break and 20-minute welcome speech. The second day consisted of an 11-hour program including one 20-minute coffee and poster session, 40-minute lunch break, and 30-minute vote of thanks and closing remarks.

The following ten simple rules are derived from experiences gained while organizing AFBIX09. We propose these as reference material to those intending to plan for similar events, with particular emphasis on resource-constrained communities.

Rule 1: Address time zone differences: timing is everything.

Allow between 6 to 9 months before the conference to permit (1) administrators in the respective virtual hubs a sufficient amount of time to finalize their decisions regarding presentation and/or attendance time slots (relative to time zones) and (2) IT departments' confirmation for the provision of necessary support, amongst other logistics, for the designated event times. The organizing committee should agree on a conference schedule that will be suitable for the time zones of all participating groups.

It is effective to create a proposed conference program for all participating groups in their local time zones to avoid confusion. Once established, it is then crucial to conduct tests of the proposed times precisely as scheduled, weeks before the actual event, to ensure the reliability of the conference program and to identify problems that could arise.

Rule 2: Test the available resources: to ensure that you are able to host the conference.

Ensure the availability of (1) a stable Internet connection; (2) a computer installed with the required video-conferencing software; (3) reliable audio speakers that have been tested for audio clarity; (4) adequate screen resolution for the capabilities of the network; and (5) a public-address system (i.e., video camera and projector connections). There should be adequate lighting for the conference hall to avoid glare or other aspects of poor visibility. Another useful resource is a standby computer assigned to the hub-coordinator with a communication application/device, such as a VoIP service, in place to ensure synchronous coordination of the proceedings with other participating hubs.

As an illustration, the last point was particularly useful in an instance where two of the participating hubs during the conference experienced network downtime, cutting off real-time presentations. Before the restoration of network connection, the respective hub coordinators had to inform the other hubs of their downtime and continually synchronize conference activities.

Rule 3: Manage bandwidth usage: to safeguard against conference interruptions.

It is critical and advisable to make sure your organizations' IT personnel are able to allocate sufficient bandwidth to the virtual conference, to avoid disruptions of live presentations (especially in organizations where network resources are shared). Alternatively, if a group of 10 or more participants are registered for the conference, it is advisable that these individuals form an independent virtual hub to save on bandwidth usage. This approach will reduce the number of Internet connections being used and thus the potential complications for your virtual conference while allowing other users an equally reliable functioning network.

Rule 4: The concept of virtual hubs: makes registration and participation simpler.

Distribute the virtual conference registration fee across all participating hubs and participants [8–12]. Cumulative hub payments ensure a reduced registration fee for the individual participant. Hubs provide local expertise and relevant local advertising for the conference. These "front porch" gathering sites compensate for some of the personal interaction that can be missing from virtual conferences. The use of virtual hubs as "conference nodes" tends to increase impact by providing access for those without the equipment and also traditional face-to face interaction. Hub participants can also share traditional meeting activities such as enjoying a meal together.

Rule 5: Prerecord presentations: to gear-up if streaming video fails for any reason.

There is a wide range of software available to get connected virtually (e.g., WebEx, Netviewer, Adobe Connect, etc.), however all available Internet systems are subject to bandwidth limitations and resulting congestion. It is therefore advisable that presentations be prerecorded and in no less than 2 weeks before the conference, in order to permit time for the recordings to be edited or redone, if necessary. Prerecorded presentations can then be hosted via the conference Web sites, making them available to the participating groups in an agreeable video format and in good time to conduct/resolve software compatibility concerns. Moreover, this allows the participants a chance to become familiar with the conference content and to play back presentations containing key concepts/information. The use of prerecorded presentations compensates for slow and unreliable networks and even intermittent electrical outages (e.g., when two of the aforementioned hubs experienced connectivity problems, they resorted to projecting prerecorded presentations to the participants in their respective hubs, and when this was resolved they were able to join the live Q&A sessions). Alternatively, if the network problems are not restored in time, the narrator can then appear online after the prerecorded presentation to answer questions in real time or to take questions via a text-based chat system.

Rule 6: Allocate time for presenter orientation: to ensure glitch-free schedule compliance.

Keynote and invited presenters should become familiar with the designated software, preferably a month before the conference. This will enable them to get acquainted with the software while allowing them to prerecord their own presentation at their convenience. Recorded presentations should then be sent to the conference host, who should test and archive all recordings before use if/when the scheduled presenter is absent at the time of his/her presentation.

Rule 7: Establish dedicated virtual interaction rooms (e-lobbies): to ensure a practical platform for participant Q&A and networking.

Each participating hub should have at least one person responsible for the collection and consolidation of all participant questions or answers from that hub. This consolidation avoids redundancy while saving time and kilobytes. Alternatively, the designated person could verbally relay the questions to the presenters on behalf of the hub to ensure clarity. This approach is especially applicable in cases where one of the hubs is in a country where the language of instruction is not the one adopted for the conference. The availability of "e-lobbies" will permit the comfortable virtual interaction of participants with similar research interests during virtual poster sessions and/or coffee breaks.

Rule 8: Troubleshoot technical glitches: to equip yourself for any foreseeable challenges.

Identify at least one person per hub to coordinate the technical set-up of the conference venue and to ensure, well in advance, that all technical equipment and relevant software are available and functioning properly.

Rule 9: Get motivated… It's the key to your success.

It is crucial to be able to set and meet your deadlines/milestones through adequate time management, hub organization, etc. Besides this, involve people who are inspired, willing, and passionate to organize the conference. Encourage participants in different hubs to take photos throughout the event. The effects of team building last long after the conference, and encouraging participation results in leadership development. Plus, the managerial skills developed play an enormous part in the success of the conference.

Rule 10: Participant feedback: useful for future reference.

At the conclusion of the conference, be sure to request feedback from the participants to be able to identify any faults or errors that can then be addressed in future events. Make sure to have all questions that were raised during the presentations and their corresponding answers available online to all participants including photos taken during the event. Aside from having this information on record, it will help sustain communication even after the virtual conference has been concluded.

The recorded videos and presentations have been made available through Bioinformatics.Org and hyperlinked on the wiki page at http://www.bioinformatics.org/wiki/Afbix09. Bioinformatics.Org seeks the opinions of the community via online polls. Blogging was not implemented in this conference, but we envisage that the online educational system operated at Bioinformatics.Org could be utilized for that in the future.

Valuable Lessons

Overall, what worked included prerecording the presentations, which were of great assistance when streaming video failed. Use of a chat facility (e.g., Skype) was key in coordinating hub activities during the course of the conference as some of the participating hubs experienced connectivity problems and had to synchronize their prerecorded presentation with the live presentations being viewed by other hubs.

What didn't work included disruption in the streaming video, which was a major drawback, and resulted in most hub coordinators relying on prerecorded videos of the conference presentations. Virtual interaction rooms (e-lobbies) were not effectively utilized as earlier anticipated; this was in contrast to the hub level where participants were able to effectively interact. It would be useful to set up subcommittees in order to deal with conference requirements as they arise. These include technical committees, fundraising committees, and scientific committees among others. It is also important for all committee members to meet regularly with the frequency of meetings increasing as the conference start date draws near.

Impact on Science in Africa

The novel idea of virtual hubs through e-conferencing was pioneered in AFBIX09. With a stable Internet connection, the maximum number of participants at any conference is dependent on whether future conferences will adopt the concept of virtual hubs. This means that the audio-visual facilities in each hub and sitting space should dictate the maximum number of persons in one hub as compared to the single user participation option. Depending on the choice of the video-conferencing software and the maximum number of connections it can allow at a given time, this value can be translated to hubs. Therefore the number of participants that can attend a virtual meeting will depend on the number of formed hubs and consequently, the maximum capacity of each hub, which may translate to thousands of participants. A new high bandwidth optical fiber cable is being laid around the coast of Africa with bandwidth improvements of 10–100 times expected around most places in Africa. This development should greatly affect future virtual activities within the continent. The African Virtual Conference on Bioinformatics (AFBIX), which was a hybrid between a normal and virtual conference, has had a large impact in the field and consequently there are plans to hold it biennially. This has impacted greatly on ISCB Regional students groups (see below) as well as other spin-off conferences such as the Indian Virtual Conference on Bioinformatics (Inbix10, http://www.bioinformatics.org/wiki/Inbix10).

In terms of participants, the Regional Student Group (RSG)-Moroccan hub had a total of 12 attendees for the AFBIX09, which enabled RSG-Morocco to develop a working relationship/collaboration with the Institut Pasteur de Tunis in Tunisia. The presentations made during the conference sparked discussions between students and scientists touching on the various topics covered, leading to the forging of new ideas on possible bioinformatics projects to undertake.

The RSG-Africa-Southern Africa hub attracted on average ten attendees for the 2 days. The hub was faced with technical issues that affected the quality of the presentations. Although overall, the attendees benefited greatly and called for improvement of future conferences.

The RSG-Africa-Eastern Africa hub attracted a total of 25 attendees as a result of a collaborative effort between the Biosciences East and Central Africa (BecA), who funded all of the students, and the International Livestock Research Institute (ILRI), who provided conferencing facilities gratis. The success of AFBIX09 prompted members to come up with plans to start collaborative bioinformatics projects between RSG-Africa-Eastern Africa and other RSGs, organizations, or institutes that will enable greater collaborations in research and training. The hub also established contacts with RSG-India, which has experience in virtual collaborative bioinformatics projects.

The RSG-Africa-Western Africa hub had a total of 17 attendees. The conference provided a platform for forging collaboration between the biological sciences and computer science departments at Covenant University, which acted as the hub for the conference. The conference attracted key administrators in their institute, including the vice chancellor, and this was a great boost for the students' group of West Africa.

The University of Notre Dame had an average range of eight to 20 attendees.In addition, three other faculties participated in the conference. This was a sure venue to foster collaboration with other students in developing countries.

The total number of participants, including speakers, organizers, and single user participants was close to 100. In conclusion, although several challenges were experienced, AFBIX09 has established a foundation for future virtual conferences.

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Editorial

Ten Simple Rules for Editing Wikipedia

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Wikipedia is the world's most successful online encyclopedia, now containing over 3.3 million English language articles. It is probably the largest collection of knowledge ever assembled, and is certainly the most widely accessible. Wikipedia can be edited by anyone with Internet access that chooses to, but does it provide reliable information? A 2005 study by *Nature* found that a selection of Wikipedia articles on scientific subjects were comparable to a professionally edited encyclopedia [1], suggesting a community of volunteers can generate and sustain surprisingly accurate content.

For better or worse, people are guided to Wikipedia when searching the Web for biomedical information [2]. So there is an increasing need for the scientific community to engage with Wikipedia to ensure that the information it contains is accurate and current. For scientists, contributing to Wikipedia is an excellent way of fulfilling public engagement responsibilities and sharing expertise. For example, some Wikipedian scientists have successfully integrated biological data with Wikipedia to promote community annotation [3,4]. This, in turn, encourages wider access to the linked data via Wikipedia. Others have used the wiki model to develop their own specialist, collaborative databases [5–8]. Taking your first steps into Wikipedia can be daunting, but here we provide some tips that should make the editing process go smoothly.

Rule 1: Register an Account

Although any visitor can edit Wikipedia, creating a user account offers a number of benefits. Firstly, it offers you privacy and security. Though counterintuitive, editors registered under a pseudonymous username actually have greater anonymity than those who edit "anonymously". A few of us have chosen to associate our accounts with our real identities. Should you choose to forgo pseudonymity on Wikipedia, your entire editing history will be open to indefinite scrutiny by curious Web searchers, including future colleagues, students, or employers. Do not forget this.

As in academic circles, a good reputation helps your wiki career. By logging in you can build a record of good edits, and it is easier to communicate and collaborate with others if you have a fixed, reputable identity. Finally, registering an account provides access to enhanced editing features, including a "watchlist" for monitoring articles you have edited previously.

Rule 2: Learn the Five Pillars

There are some broad principles—known as the "five pillars"—all editors are expected to adhere to when contributing to Wikipedia. Perhaps most important for scientists is the appreciation that Wikipedia is not a publisher of original thought or research [9]. Accordingly, it is not an appropriate venue to promote your pet theory or share unpublished results. It is also not a soapbox on which to expound your personal theories or a battleground to debate controversial issues. In this respect, Wikipedia fundamentally differs from other types of new media, such as blogs, that encourage editorializing.

Contributing to Wikipedia is something to enjoy; a natural extension of your enthusiasm for science. But differences of opinion inevitably arise, particularly on pages provided for discussion on how to improve articles. Treat other editors as collaborators and maintain a respectful and civil manner, even in disagreement [10]. If you begin to find a particular interaction stressful, simply log off and come back another time. Unlike most scientific enterprises, Wikipedia has no deadlines.

Rule 3: Be Bold, but Not Reckless

The survival and growth of any wiki requires participation. Wikipedia is unmatched in size, but its continuing success depends on the regular contributions of tens of thousands of volunteers. Therefore, Wikipedia urges all users to be bold: if you spot an error, correct it. If you can improve an article, please do so. It is important, however, to distinguish boldness from recklessness. Start off small. Begin by making minor modifications to existing articles before attempting a complete rewrite of *History of science*.

Many new editors feel intimidated about contributing to Wikipedia at first, fearing they may a mistake. Such reticence is understandable but unfounded. The worst that can happen is your first edits are deemed not to be an improvement and they get reverted. If this does occur, treat it as a positive learning experience and ask the reverting editor for advice.

Rule 4: Know Your Audience

Wikipedia is not primarily aimed at experts; therefore, the level of technical detail in its articles must be balanced against the ability of non-experts to understand those details. When contributing scientific content, imagine you have been tasked with writing a comprehensive scientific review for a high school audience. It can be surprisingly challenging explaining complex ideas in an accessible, jargon-free manner. But it is worth the perseverance. You will reap the benefits when it comes to writing your next manuscript or teaching an undergraduate class.

Rule 5: Do Not Infringe Copyright

With certain conditions, almost all of Wikipedia's content is free for anyone to reuse, adapt, and distribute. Consequently,

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it does not accept non-free material under copyright restriction. Some journals, including those from the Public Library of Science, publish material under an open-access license that is compatible with use in Wikipedia if properly attributed. Most do not. Therefore, although it may be tempting, avoid copying text or figures from your latest review article (or anyone else's) into Wikipedia. It will quickly be identified as a copyright violation and flagged for immediate deletion.

You can give Wikipedia permission to use material you own, but this process is non-reversible and can be time consuming. It is often better to rewrite the text in simpler language or redraw the figure to make it more accessible. This will also ensure it is more suitable for Wikipedia's non-expert readership (see Rule 4).

Rule 6: Cite, Cite, Cite

To maintain the highest standards possible, Wikipedia has a strict inclusion policy that demands verifiability [11]. This is best established by attributing each statement in Wikipedia to a reliable, published source (but see Rules 7 and 8 on excessive self-citing). Most scientists are in the fortunate position of having access to a wide body of literature, and experience in using inline citations to support their writing. Since unverified content may be removed from Wikipedia at any time, provide supporting citations for every statement that might be challenged by another editor at some point in the future. Whenever possible, give preference to secondary sources (such as reviews or book chapters) that survey the relevant primary research over research articles themselves.

Wikipedia's accessibility makes each of its scientific articles an excellent entry point for laypeople seeking specialist information. By also providing direct hyperlinks to reliable, freely accessible online resources with your citations (biological databases or open-access journals, for example), other editors can quickly verify your content and readers have immediate access to authoritative sources that address the subject in greater detail.

Rule 7: Avoid Shameless Self-Promotion

Many people are tempted to write or edit Wikipedia articles about themselves. Resist that urge. If you are sufficiently notable to merit inclusion in an encyclopedia, eventually someone else will write an article about you. Remember that unlike a personal Web page, your Wikipedia biography is not yours to control. A lovingly crafted hagiography extolling your many virtues can rapidly accumulate information you would rather not be publicized. You may already have a Wikipedia biography, but it contains factual inaccuracies that you wish to correct. How do you do this without breaking the rules? Wikipedia's guidelines encourage you to provide information about yourself on the associated discussion page, but please permit other editors to add it to the article itself.

Think twice, also, before writing about your mentors, colleagues, competitors, inventions, or projects. Doing so places you in a conflict of interest and inclines you towards unintentional bias [12]. If you have a personal or financial interest in the subject of *any* article you choose to edit, declare it on the associated discussion page and heed the advice of other editors who can offer a more objective perspective.

Rule 8: Share Your Expertise, but Don't Argue from Authority

Writing about a subject about which you have academic expertise is not a conflict of interest [12]; indeed, this is where we can contribute to Wikipedia most effectively. Jimmy Wales, co-founder of Wikipedia, told *Nature* that experts have the ability to "write specifics in a nuanced way", thereby significantly improving article quality [1]. When writing in your area of expertise, referencing material you have published in peer-reviewed journals is permitted if it is genuinely notable, but use common sense (and revisit Rule 7). For example, if you have an obscure, never-been-cited article in the *Journal of New Zealand Dairy Research* discussing the RNA content of cow milk, then referencing this in the introductory paragraph of the Wikipedia articles on "RNA", "Milk", "Cow", and "Evolution of mammals" is not a good idea.

Occasionally you may interact with another editor who clearly does not share your expertise on the subject of an article. This can often prove frustrating for experts and is the basis of much academic angst on Wikipedia [1]. On such occasions, remember that you are assessed only on your contributions to Wikipedia, not who you are, your qualifications, or what you have achieved in your career. Your specialist knowledge should enable you to write in a neutral manner and produce reliable, independent sources to support each assertion you make. If you do not provide verification, your contributions will be rightly challenged irrespective of how many degrees you hold.

Rule 9: Write Neutrally and with Due Weight

All articles in Wikipedia should be impartial in tone and content [13]. When writing, do state facts and facts about notable opinions, but do not offer *your* opinion as fact. Many newcomers to Wikipedia gravitate to articles on controversial issues about which people hold strong opposing viewpoints. Avoid these until familiar with Wikipedia's policies (see Rule 3), and instead focus on articles that are much easier to remain dispassionate about.

Many scientists who contribute to Wikipedia fail to appreciate that a neutral point of view is not the same as the mainstream scientific point of view. When writing about complex issues, try to cover all significant viewpoints and afford each with due weight, but not equal weight. For example, an article on a scientific controversy should describe both the scientific consensus and significant fringe theories, but not in the same depth or in a manner suggesting these viewpoints are equally held.

Rule 10: Ask for Help

Wikipedia can be a confusing place for the inexperienced editor. Learning Wiki markup—the syntax that instructs the software how to render the page—may appear daunting at first, though the recent implementation of a new editing toolbar has made this easier, and usability development is ongoing. The intersecting guidelines and policies (and the annoying tendency of experienced editors to use an alphabet soup of acronyms to reference them) can also be tricky to comprehend. Thankfully, the Wikipedia community puts great stock in welcoming new editors. Guidance is available through a number of avenues, including help desks, a specific IRC channel, and an Adopt-a-User mentorship program. You can even summon help using a special template—{{helpme}}—and, as if by magic, a friendly Wikipedian will appear to offer one-on-one assistance.

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Editorial

Ten Simple Rules for Getting Ahead as a Computational Biologist in Academia

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Getting a promotion or a new position are important parts of the scientific career process. Ironically, a committee whose membership has limited ability to truly judge your scholarly standing is often charged with making these decisions. Here are ten simple rules from my own experiences, in both getting promoted and serving on such committees, for how you might maximize your chances of getting ahead under such circumstances. The rules focus on what might be added to a CV, research statement, personal statement, or cover letter, depending on the format of the requested promotion materials. In part, the rules suggest that you educate the committee members, who have a range of expertise, on what they should find important in the promotion application provided by a computational biologist. Further, while some rules are generally applicable, the focus here is on promotion in an academic setting. Having said that, in such a setting teaching and community service are obviously important, but barely touched upon here. Rather, the focus is on how to maximize the appreciation of your research-related activities. As a final thought before we get started on the rules, this is not just about you, but an opportunity to educate a broad committee on what is important in our field. Use that opportunity well, for it will serve future generations of computational biologists.

Rule 1: Emphasize Publication Impact, Not Journal Impact

Reviewers who do not know your work well, unless told otherwise, will often judge that work primarily by the journals in which it appears. If the majority of your papers are in *Nature* and *Science*, then let the system continue to fool the reviewer. For the rest of us, it is important to emphasize that the impact of the journal does not necessarily reflect the impact of your paper. Include any data that reflect the value of your work regardless of the journal. The number of times the paper has been cited and the download statistics for that paper are obvious metrics, but should be put in context. A few citations and downloads do not necessarily mean the paper is not valuable in a narrow field. Tell the committee why it has significant impact in that field. There are also other less likely sources of support that can help. Coverage by the Faculty of 1000, press releases, blogs, and any positive commentary on the paper by others are also valuable indicators of impact.

Rule 2: Quantify and Convince

Reviewers may not be that familiar with the concept of article-level metrics and what they say about your science—where applicable, convince them in your application. Let me use an example. The very first article I wrote in this series was titled "Ten Simple Rules for Getting Published" [1]. It has been downloaded over 65,000 times, which is about 35 times per day since it was published 5 years ago. At the same time, according to Google Scholar it has been cited 30 times and according to ISI Web of Knowledge 11 times. The implication is that it has had some scholarly impact that is not reflected by the more traditional citation metric. In this case, the scholarly impact is mainly pedagogical in that it assists in professional development. This is easily overlooked by a promotion committee, but of some value in academic promotion. Metrics may not tell the whole story, for instance, in work that is relatively new. Use your application to inform the reviewers why you believe your work is significant.

Rule 3: Make Methods and Software Count

Keep statistics on software and methods use. For example, keep statistics on the number and diversity of users of the software, publications that cite the software, and the impact of those citations. For software that is modular, include the diversity of applications to which those methods and/or software have been applied. Describe what it took to develop the methods and/or software and what impact that has on the community. Many reviewers will not appreciate what it takes to develop and maintain methods and/or software for the community. Do what you can to help the reviewer with details of your time and resources, and that of others, in maintaining the software for the good of the community. Educate the committee on what open source implies, assuming your software is open source. Indicate as best you can how your efforts in software and methods bring credit to the institution.

Rule 4: Make Web Sites Count

This follows from Rule 3, but applies specifically to Web sites where Google Analytics, AWStats, and other tools can be used to quantify the impact your work has had and present those statistics to reviewers. Another irony is that papers about Web sites are rarely read, but they are highly cited if your resource is useful. Hence, they can be used to enhance your standing. Good professional conduct should dictate that you only write such papers when you have something substantively new to report regarding improvements to the Web site. Spreading citations over multiple papers just to enhance your H-factor while not adding anything substantively new speaks poorly of you and to the value system we use to evaluate scholars.

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Rule 5: Make Data Deposition, Curation, and Other Related Activities Count

Maintain records on your data-related activities, namely public accessibility, how much curation and other effort went into providing these data, and how much these data are used. Currently, there is no way to quantify the impact your public contributions of data have had on science; therefore, try to ensure that such contributions have an associated publication. Contact data resources to see if they can provide metrics for how frequently data you have contributed has been accessed and include that information in your list of accomplishments.

Rule 6: Use Modern Tools to Emphasize/Quantify Your Academic Standing

Increasingly, tools are available to impart to reviewers your scholarly standing. For example, ResearcherID from Thomson Reuters [2] will provide graphs on the total number of citations per year, average number of citations per article, and so on. However, these are only for publications found in ISI databases, which can be limited for a multidisciplinary researcher. PubNet [3] will provide your collaborative network from PubMed where each node on the network is a researcher you have published with and the thickness of edges reflects the number of times you have published together. BioMedExperts [4] provides similar data. Again, this can be somewhat limiting for multidisciplinary researchers. Bolster these statistics by indicating the full range of your scholarly activities not covered by the tools. Adding papers manually to the tracking resource can often help as well.

Rule 7: Make an Easily Digestible Quantified Summary of Your Accomplishments

Reviewers are often faced with many applications for promotion to review, and your accomplishments are easily lost in a long CV. This is particularly true if the reviewer is trying to sort out what you have accomplished in a specific time frame, as would often be the case when considering a promotion. One way to summarize accomplishments is as a bulleted list in a cover letter or some other allowable personal statement. Items on that list should include, where appropriate: published and accepted papers, pending and funded grants, including the amount coming to your institution, summarized accomplishments in software, data, and methods as per Rules 3, 4, and 5, students mentored and in what capacity, courses offered and their standing, other educational and outreach activities, company involvement, professional activities (e.g., editorial boards, scientific advisory boards), invited lectures, and awards. The idea is not to provide details here—your CV should do that—just numbers for easy and quick comprehension.

Rule 8: Make the Reviewers' Job Easy

Often, one or more of the reviewers looking at your application are going to be responsible for writing a summary of why, or why not, your advancement was granted. Again, unless the reviewers are very familiar with your work they will appreciate a candid, quantitative and honest discussion of your accomplishments. But take heed of Rule 10. Where such a discussion should be included depends on the form of your application—usually as a cover letter or part of your personal statement is appropriate. Whatever the form, it should be brief and highlight, in a way that can be understood by a non-expert, what was done and why it is of high impact and, if available, how others have followed up on the accomplishments. These highlights should be peppered with citations and quantitative data that a reviewer can easily reference should they choose to do so. More often than not the reviewer will appreciate this summation and it will be reflected in the letter they write.

Rule 9: Make the Job of Your References Easy

Often your application will include letters of support from external references, some chosen by you, others chosen by the reviewers. For the ones you choose, send those references the same summary you provide the reviewers (Rule 8). The reviewers will likely know your work well, which is why they were chosen. Notwithstanding, a good factual summary can help in their writing a reference letter, which is a significant undertaking when done well. They will thank you for it. You might even include information they would appreciate, that the committee would not—for example, specific details of research if you and the reviewer are in the same field.

Rule 10: Do Not Oversell Yourself

This may be obvious, but have an impartial third party look over your application and have them give you a candid opinion; perhaps a senior member of your institution not on your committee. Don't oversell yourself with flowery adjectives. Show, don't tell; that means, enumerate facts. If you head a laboratory, even though it is your file under consideration, it is really the work of the collective you are highlighting—be clear and fair about that. Just state the facts—if you have done well, you will do well. It is as simple as that.

I have placed significant emphasis on what to include in a cover letter or personal statement that accompanies your CV, research statement, and perhaps other materials, such as teaching evaluations. I have not discussed preparing a good CV since such information is available on the Internet and elsewhere already. What has not been covered before, as far as I am aware, is how a computational biologist in academia might maximize their chances of being promoted by a committee that is not fully appreciative of the field.

As always, we welcome your comments. I would particularly like to hear additional/alternative advice from those like myself who have been through this process a number of times. In closing, I can only offer an example of such materials that I think helped me get promoted last time around (see Text S1).

Supporting Information

Text S1 Example support letter.
Found at: doi:10.1371/journal.pcbi.1002001.s001 (PDF)

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Editorial

Ten Simple Rules for Providing a Scientific Web Resource

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Many projects in computational biology lead to the creation of a small application program or collection of scripts that can be of use to other scientists. A natural progression is to make this tool available via a Web site or by creating a service for it, from now on collectively called "Web resource."

We conducted a survey among providers and users of scientific Web resources, as well as a study on availability. The following rules reflect the experiences and opinions of over 250 scientists who have answered our questions and who use Web resources regularly, as well as our own experience. The study of availability allows us to draw objective conclusions about the characteristics of those Web resources that are still available and correlate the features that distinguish them from disappeared or nonfunctional ones. These ten simple rules aid you in designing and maintaining a scientific Web resource that is available to anyone interested in using it.

Rule 1: Plan Your Resource

As soon as you are seriously thinking about offering a Web resource to the general public, it is a good idea to lay down some ground rules. Clarify responsibilities in the processes of developing and maintaining the resource. Discuss these issues with the senior author or principal investigator, who is ultimately responsible for the availability of the resource. Read more about some ideas to manage responsibility in Rule 2.

Try to think of a good name that is not already taken and can be easily remembered. Changing the Web address of an existing resource is hard to do; it's better to start off with your own Internet domain name or a persistent URL. For the latter, the Online Computer Library Center offers a Persistent Uniform Resource Locator (PURL) for a changing Web address (for an overview, see [1]). It is essentially a transparent link to wherever your resource is currently hosted; its destination can be updated accordingly.

Some decisions early on can greatly impact the resource over its whole life cycle. Consider the level of service you want to offer. Is it a simple tool one step up from a command-line interface or a whole framework for large-scale analysis? How will users be able to access it? Read more about these options and how to make good use of the infrastructure available to you in Rule 4.

Throughout the life of your resource, there may be many different people involved in developing and maintaining it. Documentation is important for both developers and users of the resource. A scientific Web resource should be offered as open source software. Making your resource a software project at SourceForge.net, for instance, greatly facilitates development and maintenance. This also lets you keep an open channel of communications with your users, tell them about any major changes, and get their feedback to shape future developments.

Eventually, the resource may have outlived its usefulness. Read Rule 10 to find out when and how to shut down operations.

Rule 2: Discuss Responsibilities

More than 58% of resources are developed entirely by researchers without a permanent position who will eventually move to another institution.

As a graduate student, involve your advisors early when you consider providing a Web resource. Chances are, they already know a way to share the work load. Discuss the issue of software maintenance, both for the time the original developers are still on site and for the time they have moved on. Do you want to take your work with you or leave it behind?

As an advisor, remember that this issue could come up, at the latest when your student leaves. As the senior author, solving such issues are your responsibility. Feel free to direct students towards using a certain software framework; creating such lab rules limits responsibility in a good way. You can even think of creating an intergenerational treaty for software maintenance among students in different years.

If your resource is used by collaborators and they think your program is valuable enough, you could convince them to take it over. The same is true for one of the following institutions: If your resource has a high impact and is useful to many people, you may be able to convince someone at the European Bioinformatics Institute (EBI), National Center for Biotechnology Information (NCBI), Netherlands Bioinformatics Centre (NBIC), or the PSU Galaxy instance to take over. Early decisions about the framework used can have a big impact later on.

Rule 3: Know Your User Base

The most important component to consider is the Web resource audience. Come up with a use case: when and how will another researcher want to use what you are offering? When you know who you are developing for, many decisions become very straightforward. In our survey, we determined that 36% of Web resource providers think that only researchers with programming experience use their resource. If your audience can manage to run your application on their own computer, let them. It's harder to integrate a Web resource into a scripted workflow.

On the flip side, 64% of resources are also used by researchers without program-

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ming experience. They will appreciate a graphical user interface. If you know your users personally, they can give you ideas about how to make the interface fit their needs. Just watching collaborators or students use your software or programs like it will tell you a lot. Get users involved early and include them in the development process. As long as the Web resource is in use, you can solicit feedback from users and see if their needs have evolved (cf. Rule 7).

Constant monitoring of usage patterns and access statistics can be achieved by tracking who visits the Web resource page. If your institution is not already collecting these data from visitors, you can set up a free Web analytics tool within minutes.

Most scientists will come to your Web site via a search engine. Use the indexing power of the search engine spiders by putting, for example, the paper title, abstract, and keywords on the page. When you follow the tips about naming your resource in Rule 1, it should be easy to find.

Rule 4: Use Services Available to You during Development

The finest way out of much of the strife with hosting and availability is to find someone else to take care of it. If you work on a larger campus or cooperate with someone at an institution that already runs several scientific Web resources, get in touch with the administrators to set up your tool on an established server. Such decisions can greatly influence the software development process. Be aware of the Web address you use to publish your resource. It's best to use a persistent URL or your own domain name for the resource to make sure it is always available under the published address (cf. Rule 1).

Estimate the number of potential simultaneous users. Together with the memory and compute time requirements, this will tell you about the kind of infrastructure you will have to provide to make the resource usable even with many queries coming in at the same time. In an age of high-throughput experiments, this can be a lot. To get an estimate on the number of simultaneous queries your setup can handle, you can perform a stress test, sending a high number of requests with a script from an external source.

If your requirements seem enormous, consider optimizing your program further and finding redundancies between individual queries that can be pre-computed and stored. You can also offer an interface to a cloud-computing on-demand resource, so users are paying for their own computing time. Providing your own large-scale computing infrastructure can be very costly.

You will have to think about a user interface for your resource. Here, an existing framework can save you a lot of time. Examples include Taverna [2], where you provide a description of the input and output in the Web resource description language. Your resource is accessed from a client workbench, in which users can connect your program's output to others to create workflows. It still runs on your own servers and you have to provide the necessary software infrastructure for that.

Galaxy [3] is a customizable workbench that you can download and run on your own Web server. It lets you integrate any command-line tool with a few lines of XML; moreover, it even lets you connect your own tools with the pre-packaged ones to create transparent workflows for your users. You don't need to think about file management and pretty user interfaces, and for those time-intensive jobs, you can easily connect your Galaxy instance to a compute cluster or even run it in the cloud.

If you want to build an interface from scratch, there are also frameworks that make this task easier. Aside from the classic Apache, SQL, and PHP combination, there are a few more modern alternatives: take a look at Ruby on Rails, Tomcat, Pyjamas, or CherryPy.

Rule 5: Ensure Portability

Make sure that you can still install and run the software on another machine. If you want your software to be available three years from now, consider this strongly. Chances are that the server you are developing on will be replaced or software is updated, which often breaks the functionality. Ensuring portability also makes it easier for computational biologists to install your software locally. Ask a colleague to install the resource from scratch on another computer and you'll see where the pitfalls are.

A brute-force approach to portability is creating a virtual machine (VM). If you have a server where your resource runs just fine, back up its hard disk and restore it in a VM like VirtualBox. That way, you have a running version of your server in a single file. The VM approach is a steamroller tactic for resources with very intricate dependencies. This is a way to provide users with the necessary disk image to run your resource on the compute cloud. However, it is still advisable to provide information on how to set up your program from scratch. Together with source code comments and a high-level user manual, these three layers of documentation will ensure portability.

Rule 6: Create an Open Source Project

Your source code should be public if the results are used in scientific publications. This is needed for reproducibility (read more about this in Rule 8).

To make your life easier, it is a good idea to place your source code in a repository such as SourceForge.net [4] or Bioinformatics.org [5]. Then you don't have to take care of version control and release issues and it's easier for collaborators to work together over distance. Most of these open source software project sites provide developers a means of communication both with each other and with end users. You can choose between mailing lists (with an online archive), a Web site forum, or an FAQ page.

Many scientists develop programs for one of the proprietary mathematical environments that require expensive licenses to run. If you are still in the planning stage, consider switching to an open source alternative. Your funding body may not be willing to pay for a score of licenses just for the users of your Web resource.

Using open source software, good source code documentation, and standard file formats will go a long way in making your software able to run on other computers (cf. Rules 5 and 7).

Rule 7: Provide Ample Documentation and Listen to Feedback

A good first impression is very important for Web resources, too. It is crucial that first-time users feel welcome on your site. Provide good documentation and some short info about parameter settings, that is, accepted ranges and optional settings. Ideally, there is a one-click testing possibility with meaningful but easily understood example data. If the output of the example is well-defined, set it up to run periodically as a functional test, for instance during the build process.

Nothing teaches you about parameter settings, file formats, and the general purpose of a resource like a well-crafted demonstration of what it can do, for instance, in a video or screen cast. Many of these points are part of journals' instructions to authors and therefore required when submitting a research article about your Web resource.

A main complaint of the interviewed scientists about working resources was lack of documentation (41%). Beyond the reference to the paper to be cited when using the resource, you should include a brief overview of the resource's purpose, for what kinds of data it is applicable, and pointers to common pitfalls or preprocessing steps that are not so obvious. The latter is hard to imagine beforehand, so find out from users what they consider difficult.

It will be worth your while to set up a channel of communication with your users. Many source code repositories provide such functions (cf. Rule 6), which will save you a lot of time responding to frequent questions users ask about the resource. You can post announcements about maintenance, updates, and bug fixes, and best of all, experienced users often will be there to answer recurring questions raised by newbies, or you can refer them to the collective wisdom of the archives. It is also common practice to provide an e-mail address where the authors can be reached.

Make your life easier by providing a comprehensive error report option that users can click on when something fails, thereby e-mailing you all the information you need to find out what went wrong.

There are two more layers of documentation: in addition to the high-level help for end users, installation instructions will ensure portability, and good source code comments enable you to hand over maintenance responsibility to another developer, maybe even from the user community (cf. Rule 9).

Rule 8: Facilitate Reproducibility

Reproducibility is always a topic of discussion in computational biology. When a user analyzes data with your Web resource, the results may end up in a research article. Therefore, all the steps needed to reproduce these results have to be documented entirely. In your output, provide users with details about the parameter settings they used, the version number, and information about the input data.

Everything to run the analysis again should be available to reviewers and readers. This includes the source code of the Web resource itself (cf. Rule 6).

It is good practice to make available older versions of the resource for purposes of reproducing results; at least boldly display the Web resource's current version number on the site and hints about how changes may affect the output.

If you change the server's behavior, your users have to know. Even if it is merely a bug fix, be sure to report it publicly in a place that will be noticed when using the server. Keep in mind that some users, for example, may have bookmarked the data submission page.

Rule 9: Plan Ahead: Long-Term Maintenance

You will probably move to another place during your career. If you leave behind a Web resource, try to make the transition to the new maintainer as smoothly as possible. Ideally, a protocol has already been established during the planning phase (cf. Rule 1). In our survey, we found that more than 24% of Web resources will not be maintained after the original developers leave. Ultimately, it is the responsibility of the senior author of a publication to make sure that this does not happen, but it is a very important consideration for all authors of a Web resource publication.

Documentation of the source code and the installation process will greatly facilitate the transition to new maintainers. If there is no one in your old lab to take over, but the resource is still heavily used, you may be able to convince a current user or a collaborator to take over maintaining the resource. This will be even easier if the program is an open source software project, where a new developer can join at any time.

You may want to take your software with you and find a new home for it. In some circumstances, this requires you to change the Web resource's address. If your resource has been published in a journal, try contacting them and ask to have the link to your resource updated. Some journals may require a formal correction. Get your previous institution to link or forward to the new address from the old page for as long as possible. If you used a persistent URL, all you need to do is update the link (cf. Rule 1).

Rule 10: Switch off an Unused Resource

During our study, we determined that, while a surprising number of Web resources are still available after a long time, they may not always work any longer. For users, this can be even more frustrating than an unavailable page.

If your resource is no longer under active development, chances are that it has outlived its usefulness after some years. After that, check to see if there is anyone still using it or if the original publication has been cited recently. This should be easy when you followed the advice about collecting statistics in Rule 3. If no one is using your resource any longer, release the source code one last time, and you're done.

If the resource is still useful to some researchers, try posting a notice on the site asking for someone to take over (cf. Rule 9). If all of that seems like too much work and the source code alone won't help anyone, consider creating a VM that runs the resource. When you still have access to the server, this can be done in a matter of hours.

By following these rules, your resource will have a long and productive life.

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Editorial

Ten Simple Rules for Building and Maintaining a Scientific Reputation

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While we cannot articulate exactly what defines the less quantitative side of a scientific reputation, we might be able to seed a discussion. We invite you to crowd source a better description and path to achieving such a reputation by using the comments feature associated with this article. Consider yourself challenged to contribute.

At a recent Public Library of Science (PLoS) journal editors' meeting, we were having a discussion about the work of the Committee on Publication Ethics (COPE; http://www.publicationethics.org/), a forum for editors to discuss research and publication misconduct. Part of the discussion centered on the impact such cases have on the scientific reputation of those involved. We began musing: What on earth is a scientific reputation anyway? Not coming up with a satisfactory answer, we turned to a source of endless brainpower—students and other editors. Having posed the question to a group of graduate students, PLoS, and other editors, we got almost as many different answers as people asked, albeit with some common themes. They all mentioned the explicit elements of a reputation that relate to measurables such as number of publications, H factor, overall number of citations etc., but they also alluded to a variety of different, qualitative, factors that somehow add up to the overall sense of reputation that one scientist has for another.

What these students and editors identified en masse is one important side of a scientific reputation that is defined by data; but they also identified a much more nebulous side, that, while ill-defined, is a vital element to nurture during one's career. A side defined to include such terms as fair play, integrity, honesty, and caring. It is building and maintaining this kind of less tangible reputation that forms the basis for these Ten Simple Rules. You might be wondering, how can you define rules for developing and maintaining something you cannot well describe in the first place? We do not have a good answer, but we would say a reputation plays on that human characteristic of not appreciating the value of something until you do not have it any more.

A scientific reputation is not immediate, it is acquired over a lifetime and is akin to compound interest—the more you have the more you can acquire. It is also very easy to lose, and once gone, nearly impossible to recover. Why is this so? The scientific grapevine is extensive and constantly in use. Happenings go viral on social networks now, but science has had a professional and social network for centuries; a network of people who meet each other fairly regularly and, like everyone else, like to gossip. So whether it is a relatively new medium or a centuries-old medium, good and bad happenings travel quickly to a broad audience. Given this pervasiveness, here are some rules, some intuitive, for how to build and maintain a scientific reputation.

Rule 1: Think Before You Act

Science is full of occasions whereupon you get upset—a perceived poor review of a paper, a criticism of your work during a seminar, etc. It is so easy to immediately respond in a dismissive or impolite way, particularly in e-mail or some other impersonal online medium. Don't. Think it through, sleep on it, and get back to the offending party (but not a broader audience as it is so easy to do nowadays with, for example, an e-mail cc) the next day with a professional and thoughtful response, whatever the circumstances. In other words, always take the high road whatever the temptation. It will pay off over time, particularly in an era when every word you commit to a digital form is instantly conveyed, permanently archived somewhere, and can be retrieved at any time.

Rule 2: Do Not Ignore Criticism

Whether in your eyes, criticism is deserved or not, do not ignore it, but respond with the knowledge of Rule 1. Failure to respond to criticism is perceived either as an acknowledgement of that criticism or as a lack of respect for the critic. Neither is good.

Rule 3: Do Not Ignore People

It is all too easy to respond to people in a way that is proportional to their perceived value to you. Students in particular can be subject to poor treatment. One day a number of those students will likely have some influence over your career. Think about that when responding (or not responding). As hard as it is, try to personally respond to mail and telephone calls from students and others, whether it is a question about your work or a request for a job. Even if for no other reason, you give that person a sense of worth just by responding. Ignoring people can take other serious forms, for example in leaving deserving people off as paper authors. Whether perceived or real, this can appear that you are trying to raise your contribution to the paper at the expense of others—definitely not good for your reputation.

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Philip E. Bourne is Editor-in-Chief of *PLoS Computational Biology*. Virginia Barbour is Chief Editor of *PLoS Medicine* and Secretary of COPE.

Rule 4: Diligently Check Everything You Publish and Take Publishing Seriously

Science does not progress in certainties—that is one of its joys but also what makes it such a hard profession. Though you cannot guarantee that everything you publish will, in 50 years' time, be shown to be correct, you can ensure that you did the work to the accepted standards of the time and that, whether you were the most junior or senior author, you diligently checked it (and checked it again…) before you submitted it for publication. As a first author you may well be the only one who appreciates the accuracy of the work being undertaken, but all authors have a responsibility for the paper. So, however small or big your contribution, always be upfront with your co-authors as to the quality and accuracy of the data you have generated. When you come to be a senior author, it is so easy to take a draft manuscript at face value and madly publish it and move on. Both actions can come back to haunt you and lead to a perception of sloppy work, or worse, deception. As first author, this mainly lets down your other authors and has a subtle impact on your growing reputation. As the senior author of an error-prone study, it can have a more direct and long-lasting impact on your reputation. In short, take publication seriously. Never accept or give undeserved authorship and in addition never leave anyone out who should be an author, however lowly. Authorship is not a gift—it must be earned and being a guest or gift author trivializes the importance of authorship. Never agree to be an author on a ghostwritten paper. At best these papers have undeclared conflicts of interest; at worst potential malpractice.

Rule 5: Always Declare Conflicts of Interest

Everyone has conflicts of interest, whether they are financial, professional, or personal. It is impossible for anyone to judge for himself or herself how their own conflict will be perceived. Problems occur when conflicts are hidden or mismanaged. Thus, when embarking on a new scientific endeavor, ranging from such tasks as being a grant reviewer, or a member of a scientific advisory board, or a reviewer of a paper, carefully evaluate what others will perceive you will gain from the process. Imagine how your actions would be perceived if read on the front page of a daily newspaper. For example, we often agree to review a paper because we imagine we will learn from the experience. That is fine. Where it crosses the line is when it could be perceived by someone that you are competing with the person whose work you are reviewing and have more to gain than just general knowledge from reviewing the work. There is a gray area here of course, so better to turn down a review if not sure. Failure to properly handle conflicts will eventually impact your reputation.

Rule 6: Do Your Share for the Community

There is often unspoken criticism of scientists who appear to take more than they give back. For example, those who rarely review papers, but are always the first to ask when the review of their paper will be complete; scientists who are avid users of public data, but are very slow to put their own data into the public domain; scientists who attend meetings, but refuse to get involved in organizing them; and so on. Eventually people notice and your reputation is negatively impacted.

Rule 7: Do Not Commit to Tasks You Cannot Complete

It tends to be the same scientists over and over who fail to deliver in a timely way. Over an extended period, this becomes widely known and can be perceived negatively. It is human nature for high achievers to take on too much, but for the sake of your reputation learn how to say no.

Rule 8: Do Not Write Poor Reviews of Grants and Papers

Who is a good reviewer or editor is more than just perception. Be polite, timely, constructive, and considerate and, ideally, sign your review. But also be honest—the most valued reviewers are those who are not afraid to provide honest feedback, even to the most established authors. Editors of journals rapidly develop a sense of who does a good job and who does not. Likewise for program officers and grant reviews. Such perceptions will impact your reputation in subtle ways. The short term gain may be fewer papers or grants sent to you to review, but in the longer term, being a trusted reviewer will reflect your perceived knowledge of the field. Although the impact of a review is small relative to writing a good paper in the field yourself, it all adds up towards your overall reputation.

Rule 9: Do Not Write References for People Who Do Not Deserve It

It is difficult to turn down writing a reference for someone who asks for one, even if you are not inclined to be their advocate; yet, this is what you should do. The alternative is to write a reference that (a) does not put them in a good light, or (b) over exalts their virtues. The former will lead to resentment; the latter can impact your reputation, as once this person is hired and comes up short, the hirer may question aspects of your own abilities or motives.

Rule 10: Never Plagiarize or Doctor Your Data

This goes without saying, yet it needs to be said because it happens, and it is happening more frequently. The electronic age has given us tools for handling data, images, and words that were unimaginable even 20 years ago, and students and postdocs are especially adept in using these tools. However, the fundamental principle of the integrity of data, images, and text remains the same as it was 100 years ago. If you fiddle with any of these elements beyond what is explicitly stated as acceptable (many journals have guidelines for images, for example), you will be guilty of data manipulation, image manipulation, or plagiarism, respectively. And what is more, you will likely be found out. The tools for finding all these unacceptable practices are now sophisticated and are being applied widely. Sometimes the changes were done in good faith, for example, the idea of changing the contrast on a digital image to highlight your point, but one always needs to think how such a change will be perceived and in fact whether it might, even worse, give the average reader a false sense of the quality of that data. Unfortunately, even if done in good faith, if any of these practices are found out, or even raised as a suspicion, the impact on one's career can be catastrophic.

In summary, there are a number of dos and don'ts for establishing a good reputation—whatever that might be. Do not hesitate in giving us your thoughts on what it means to be a reputable scientist.

Editorial

Ten Simple Rules for Getting Help from Online Scientific Communities

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Introduction

The increasing complexity of research requires scientists to work at the intersection of multiple fields and to face problems for which their formal education has not prepared them. For example, biologists with no or little background in programming are now often using complex scripts to handle the results from their experiments; vice versa, programmers wishing to enter the world of bioinformatics must know about biochemistry, genetics, and other fields.

In this context, communication tools such as mailing lists, web forums, and online communities acquire increasing importance. These tools permit scientists to quickly contact people skilled in a specialized field. A question posed properly to the right online scientific community can help in solving difficult problems, often faster than screening literature or writing to publication authors. The growth of active online scientific communities, such as those listed in Table S1, demonstrates how these tools are becoming an important source of support for an increasing number of researchers.

Nevertheless, making proper use of these resources is not easy. Adhering to the social norms of World Wide Web communication—loosely termed "netiquette"—is both important and non-trivial.

In this article, we take inspiration from our experience on Internet-shared scientific knowledge, and from similar documents such as "Asking the Questions the Smart Way" [1] and "Getting Answers" [2], to provide guidelines and suggestions on how to use online communities to solve scientific problems.

Rule 1. Do Not Be Afraid to Ask a Question

Some people are afraid of asking a question in public, for fear of appearing ignorant or foolish. Other people worry about their ability to express the question proficiently or with the correct grammar.

Actually, asking a question in a public website is a good thing. First, the process of composing a message to explain a problem is itself a great exercise. Second, it is a great way to learn faster, and to enter into contact with people from different fields. Third, and more importantly, your career will be difficult if you do not learn how to get help from other people.

As Albert Einstein once said, "The important thing is not to stop questioning. Curiosity has its own reason for existing" [3]. Asking the right questions should always be a priority in science, and online communities are a good place to practice.

Rule 2. State the Question Clearly

The key to getting a good answer is to ask the question in a clear and concise way. If your question is too long, many people simply will not read it. On the contrary, if your question is too short, people may interpret it incorrectly and give you an erroneous answer.

A way to keep your questions short and concise is to systematically break down the problem into smaller parts. This can help you to decide where to seek help, and how much to seek. If you feel your problem is composed of multiple questions, then post as many messages as needed. You should start a separate discussion thread for each of the problems you want to solve, avoiding mixing messages about different topics together.

On the other hand, you should provide enough details so that people can answer you without having to ask you for additional explanations. Read the message you wrote carefully, and think about which details you forgot to include. A reader should be able to answer you just by reading your initial message, without having to look at the rest of the discussion, or at what other people already have said in response.

Some examples of non-concise questions and how to improve them are shown in Text S1. Spend as much time as you need in preparing your initial message: this will save time later and will lead you to find the best solution more easily. Many people are surprised to see how some-

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times, in thinking about how to pose the problem, the answer reveals itself!

Rule 3. New to a Mailing List? Learn the Established Customs before Posting

A common error is to rush into a web forum and start asking something without understanding how its web interface works and which people use the resource. Instead, a good habit is to spend a few days, after having created an account, reading the discussions published and practicing with the web interface. You will see which people use the forum or mailing list, which rules of netiquette are used, which kind of questions are asked, and how much time it takes to obtain an answer. For this reason, it is a good idea to subscribe to a few mailing lists or forums on your topics of interest even when you do not urgently require anything from them. This will show you the concrete ways in which people post messages.

Remember that you may have to use a different language depending on the audience you are addressing. For example, some technical terms may be understood in one mailing list or community but not in others. People who do not study genomics might not immediately know how to respond to questions about GWASs, SNPs, or STRs (genome-wide association studies, single nucleotide polymorphisms, and single tandem repeats, respectively).

Rule 4. Do Not Ask What Has Already Been Answered

People in general do not like to repeat their explanations. Before posting a question, use a search engine to see if a similar question has been asked previously. You should post a new question only if the answers you have found are not satisfactory. In case you decide to post a new question, cite the previous answers and explain why they are not sufficient to solve your problem. This demonstrates that you have already researched the answer on your own. Most discussion forums or mailing lists also have a searchable archive, which should be consulted before posting a question.

Rule 5. Always Use a Good Title

People like to quickly skim through titles, looking for questions within their expertise that they are able to answer. So, you will have to be good at catching the attention of the readers that can help you. Use a clear and concise title, so that readers can decide whether they are able to respond to your message without having to read the whole message.

An approach to choosing a good title is to think of a hypothetical web search query that you would use to find a solution to your problem. For example, where you might search for "format BLAST database," an adequate title for a forum post could be "How do I format a BLAST database?" or "Formatting a BLAST database." More specificity, within reason, is preferable.

At the same time, it is important not to waste the time of the people who are not able to help you, and are not interested in what you are writing. Refrain from attempts to attract attention with titles such as "Help me" or "Urgent." People usually do not appreciate these kinds of titles because each forum member must then view the post in order to understand what you are asking. If you use incorrect titles, your message may be censured or closed by the moderators, and you may be forbidden to use the resource.

Some examples of good and bad titles are shown in Text S1.

Rule 6. Do Your Homework before Posting

People in an online community are willing to help, but are not there to work for you. You should always show that you have first tried to solve your problem by yourself. Explain clearly what you have done, and describe the approach that you took.

When asking for help to solve an assignment, always explain how you have tried to solve it. Many students from bachelor programs use web forums and mailing lists to copy-paste the assignments given by their teachers, and call on other people to show them how to solve them. This behavior is not well received and can bring you a bad reputation.

However, you can nonetheless ask for help on how to solve an exercise if you demonstrate that you have made some effort in solving it. Show what you have done so far, and why you think it is not correct. Ask other people to check your solution, not to give the solution to you.

When asking about a programming issue, do not expect other people to write a whole program for you: rather, post an example of the code that you have written and where you are stuck. Include an example of the input and the expected output of your program. If you receive error messages, also include the full output of the error. This will help the other users to inspect your logic, to test the code on their own computers, and to easily pinpoint the problem therein.

If you ask a question about a software package, make sure that the solution is not already answered in the user manual or the Frequently Asked Questions (FAQs) before bringing your question to a forum. Also, declare that you have already checked these sources.

If you really need another person to write a program or a task for you, then explain that you are looking for a collaboration, and say how you will acknowledge a correct answer. If you explain everything well, your reputation online will also improve.

Rule 7. Proofread your Post and Write in Correct English

Using correct grammar is important. Readers will be more likely to answer if the question is clear and correctly posed. Your grammar does not need to be academic, but it must be intelligible to a broad audience. Avoid slang and abbreviations as much as possible, to show that you have made at least some effort in writing a clear message. Writing in capital letters or in unconventional styles, such as that of text messages, is usually unwelcome, and in the long term can deteriorate your reputation online.

Your message should be as concise as possible. You do not need to introduce yourself on every message; doing it only once will be enough. Be careful of using too many adverbs and adjectives, or unnecessary changes in verb tense, as they may make the text difficult to understand. Also, do not be afraid of repeating technical terms more than once, as using too many synonyms will only make the text more difficult to understand.

This rule may be the most difficult to follow for non-native English speakers. A good approach is to spend some time reading the messages written by other users of the forum or the mailing list and follow their example. Search for a question similar to what you want to ask, and use it as a model; you may even copy and paste some portions of the text if it helps you to formulate a correct question.

Rule 8. Be Courteous to Other Forum Members

Members of a discussion forum are usually unpaid volunteers who offer their time and expertise by volition and not by obligation. They are therefore not obliged to answer any questions at all.

Maintaining civil and polite conversations fosters an environment that encourages people to contribute. You must remember that forums are as human as their users, and you may sometimes receive a perfect answer written in an unfriendly tone. This can happen for various reasons: perhaps the same question was asked previously, or maybe the author was in a bad mood when writing. For your career, it is crucial that you not permit the discussion to degenerate into an argument. Even if you receive an impolite answer, stay calm and answer as gently as you can [4]. And remember the golden rule: treat other forum members as you wish to be treated.

One of the most impolite behaviors toward an online community is asking a question in multiple places at the same time. "Cross-posting", as this practice is called, can make two distinct online communities work through a solution for you when only one is needed; this is an abuse of forum members' time. If you have not received an answer and you believe that asking it in another place would get you one, provide a link back to the original discussion. Similarly, if you receive an answer in a different forum, report the answer to the original forum. Then, the people who helped you will know what the correct solution is and that you are no longer looking for it.

Rule 9. Remember That the Archive of Your Discussion Can Be Useful to Other People

Messages in a mailing list or forum remain archived on the Internet. In certain situations, this can be a source of trouble: check the policy of your university or employer regarding posting on the Internet; avoid spreading embargoed information; and if possible, use your academic/corporate email address when registering, to keep your private life separated from your work.

Nevertheless, most of the time it is possible to make use of online communities without breaking any of your employer's rules. In these cases, the fact that an archive of the discussion remains publicly accessible is positive, as it becomes a useful resource for people searching for solutions to similar problems. Several knowledge archives are actively saving bioinformatics-related questions from open source projects. For example, questions about BioPerl [5] are kept in the GMANE (http://news.gmane.org/gmane.comp.lang.perl.bio.general) and Nabble archives (http://old.nabble.com/BioPerl-f13596.html).

Since an archive of the discussions remains available on Internet, it is good practice to conclude the discussion by indicating the correct solution to the problem exposed or by summarizing the suggestions received. If some of the answers that you received have proven to be wrong, do not be afraid of writing it in the online discussion: this will help other people avoid trying an erroneous solution. Even if you did not receive any useful answers, sacrifice a bit of your time to thank the people who tried to help you and to explain that you were not able to find a solution.

Rule 10. Give Back to the Community

Have you found your answer? Great! As time progresses and you get more experienced in the respective field in which you asked your question, you might want to start contributing the knowledge that you have gained by helping people that are now in your previous position. Most online communities are very welcoming to new members, as they alleviate the work of more experienced ones. Also, as a new contributor, you might be able to see problems from a beginner's point of view. You do not have to contribute to the community by answering questions, as some communities have a "wiki-style" interface where you can contribute by editing, tagging, or flagging questions. In any case, following at least a few science-related mailing lists and contributing actively to them is a great way to come into contact with researchers working in your field, and over time can lead you to new collaborations and new opportunities for your career.

Supporting Information

Table S1 List of bioinformatics- and biology-related mailing lists and communities.
(DOC)

Text S1 Examples of poorly posed questions, and how to improve them.
(DOC)

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Editorial

Ten Simple Rules for Getting Involved in Your Scientific Community

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A scientific community consists of scientists working in a particular field of science and, most importantly, of their relationships and interactions. Beyond the traditional publication of research projects, discussions occurring during conferences, seminars, and even online through social networks or blogs enable ideas to spread more efficiently and are essential for building a lively and dynamic community. Activities such as organizing conferences and workshops, answering questions and discussing scientific ideas online, contributing to a scientific blog, or participating in open source software projects are typically thought of as outside classic research activity. Having scientists involved in those activities, however, is very important for the community to be dynamic and to promote fruitful discussions and collaborations. Scientific associations have an important role in enabling science by bringing people together and giving them a voice. Moreover, being involved in such activities is individually very rewarding because it enables scientists to acquire new skills not typically taught and to expand their network and interactions.

For those reasons, I encourage young scientists to get involved in their scientific community. However, it should be noted that this involvement takes time during which you are not directly contributing to your research projects and publications. It is thus essential to balance those activities. The purpose of this paper is twofold: i) illustrate some of the benefits of being involved and, most importantly, discuss how to get there; and ii) give some concrete advice and rules to keep this involvement as effective and controlled as possible in order to serve the community and receive benefits in return without hampering your research activity.

In scientific societies or associations, many tasks are accomplished by individuals who volunteer their time. Even tasks that appear to be merely administrative or clerical are essential for the scientific community and will make a difference in your field. In those volunteer organizations, projects are often driven by a single person or a very small team. Consequently, volunteers often have to take initiative and take things into their own hands. That is the context in which these rules should be of particular interest.

I have been involved in the Student Council of the International Society for Computational Biology for five years, progressively taking on more responsibilities, in particular in the organization of conferences (co-chair of the symposium in Boston in 2010 and chair of the first European symposium in Ghent in 2010), but also more generally in the Student Council (I was secretary—one of the elected leaders—of the Student Council in 2009). In addition, I created the French Regional Student Group (RSG-France), which I chaired for two years. This paper is based on my experience in the bioinformatics community, but also on associative involvement I had outside science. Most examples are taken from the bioinformatics community, but I believe the rules are rather general and apply for other communities.

Rule 1: Collect Information

Maybe you are not sure whether you want to get involved or not and which kind of involvement is possible and would be interesting for you. The first thing to do is certainly to ask people around you about their experience in various associations and committees, should it be in your scientific community or other communities. You can ask them about the kind of involvement they have or had and what they like or dislike about it. Which were the benefits? Which were the problems? Would they do it again? All these questions can help you get a more concrete idea. In addition, you can search on the Internet and look for information about societies or associations you are interested in, if they exist. If they don't, it can also be good to create something new, but that is more challenging and may not be appropriate for a first experience.

Rule 2: Define What You Want and Expect

It is important to know why you are getting involved and to define a clear goal. This will help you keep the motivation. For instance, you want to be part of a team of international students to improve your communication skills, or you want to learn how you can raise funds and contact sponsors. Maybe you want to get experience in organizing a conference or simply meet new colleagues all around the world. Defining what you will get or expect to get from the involvement is certainly a good idea. You might realize afterwards that you actually got very different benefits from what you were expecting, but it is good to think about it at first.

Rule 3: Define Your Boundaries

To keep the balance between your activities you need to define clear boundaries, in particular to what extent you want to get involved. If you don't know what you are doing, you don't know when to stop. This is true for the daily work when you are wasting a lot of time simply because the task is not clear. But it is also valid for the duration of your involvement. It may be a good idea to decide beforehand when you want to stop. Do you plan to be involved two years? Three years?

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Until you get your PhD? Until you finish your postdoc or any other project? It may be easier to get involved after you have settled in your current place and project, as opposed to during phases of transition.

Rule 4: Jump into the Pool and Get Involved

Now you want to get involved, you know why, and you have a goal and boundaries. But how can you actually start? Keep in mind that it may be enough to simply be open to any good opportunity that can unexpectedly happen. Haven't you been asked already to help out with the organization of an event or the reviewing of some abstracts? Otherwise, you will need to be proactive to get involved, and there are many ways to start. For instance, you can send an e-mail to a committee chair or the society chair asking questions about how it works or how you could help. You can even indicate your interest if you have some ideas or know what you would like to do, but it is certainly not required. Don't hesitate to contact people and just ask if there is anything you can do to help. Help is often needed and very appreciated. You can also attend the annual meeting of the society, join a committee, or participate in mailing list discussions. Even when you are already involved you can be proactive about taking on more responsibilities. If would like to do more, or change what you are working on, let people know and offer to do something different or new. It is always very motivating for the team to see that volunteers want more responsibilities.

Rule 5: Let Other People Know What You Want to Do

Everybody has different interests and it is key to know them to build a team as effective as possible. If Joe hates contacting potential sponsors but likes writing meeting reports, he will be happy to know that William would rather be part of the fundraising effort and hates writing reports. Thus, be clear about your interests for the benefit of everybody. Following this idea, it is important to be clear with yourself and with others about what you can or can't do. You have to realize that you are part of a team. The point is not to do everything, or to take as many tasks or responsibilities as possible to show you are very much involved. The point is to commit to what you can do and to do it (and do it as well as you can). If you have some more time, you can always ask for more, help on other tasks, and get more involved. But if you can't deliver what you signed up for, you penalize the team and the work of other people. You can think of it as a soccer team—if you commit for a game and don't show up, the team is stuck.

Rule 6: Dedicate Regular Time

It is extremely important to work regularly even when you are busy. It is indeed very likely that your research will take up all the time that is not firmly reserved for other activities. Thus, if you don't take your involvement as seriously as your research, you will never get anything done. When you feel overwhelmed, postponing everything for later when you expect to have more time is generally not a good strategy, because you will always be busy. It is often the case that 10 or 15 minutes on a project can be enough to get the next step done. Think about where you are and what is the next step. Maybe you just need to send an e-mail to ask about the quotes Jack had to get, or remind this keynote speaker about the picture he has to send. However, we still have some periods when it is more difficult than usual to dedicate the smallest amount of time. In that case, be clear about it and try to give your expected schedule and deadlines in advance so that other people on the team can adjust.

Rule 7: Organize Your Time

Since you can't spend all your time on your community involvement and want to maintain a balance with the activities directly related to your research projects, it is essential to get organized. You can decide in advance how much time you want to dedicate and track the time you actually spend on your various activities. You might realize that some tasks take much more time than you were expecting or, conversely, are much faster to perform than you initially thought. The more you do it, the more accurate you become in your time estimates. This will enable you to know precisely which responsibilities and tasks you are able to handle and to be reliable in your commitments. As part of your schedule, you also want to define realistic milestones and deadlines, and stick to them.

Rule 8: Work in a Team

Unless you are really working on a project alone, you will likely be part of a team and you should take advantage of it. Thus, don't take all the work for you, and remember that you are not alone. Keep in mind, particularly if you lead a team, that you need to distribute the work, delegate some tasks to others, and ask for help when you need it. In general it is good to assign a single responsible person and a deadline for each task. Working with other people is also an interesting way to get feedback on your work and ideas. Even though it usually takes more time, it is a good idea to suggest a discussion and take the opportunity to get comments on your ideas, actions, and concerns. That is what teamwork is about. Finally, this is probably more geared towards leaders, but it is extremely important to be able to get the best out of a group of different and complementary volunteers. Identify the strengths and weaknesses of your team workers and help everybody achieve their best based on their interests and skills. Identify and respect the differences of the people in the team. In particular, in international associations you will likely be interacting with people from all over the world who may have cultural differences in work styles, expectations, and ways to communicate. In line with this, it may be useful to provide an action item list with concrete tasks that allows people to find where they can help in the project.

Rule 9: Encourage Others to Get Involved

Don't hesitate to let your colleagues know about your involvement. The point is not to show them how great you are doing and that they should do the same. But it is very likely that many people are not aware of this kind of involvement and don't realize how useful it is for the community and for you. Explain the work you are doing and what you get from it. You can encourage your colleagues to play an active role in the scientific community. If you think that someone would be effective in some specific task, tell him or her so. Sometimes people don't realize that they are good in specific tasks that seem complicated for others. For instance, you can ask Averell, who has very good graphical skills, to work on the design of various documents, flyers, or posters. Since the organization is composed of volunteers, it is often the case that people have to step down from their position when their job situation changes. Thus, it is important to have other volunteers who can take over. But it is also important to get new people to bring fresh ideas, new perspectives, and different ways to work. When you start to know people and have experience working with them, for example, in organizing a conference, you can be very effective doing similar tasks again.

Nevertheless, it is rewarding to get new people involved and to have new comments from outside, even if it seems more complicated and takes more time. Last but not least, you should guide interested people to get involved. Many people would be happy to help but don't take the time to actually start, or don't feel confident enough. If you mentor them in the beginning, it might be enough for them to get into it.

Rule 10: Enjoy as Much as Possible

What you like, you will do great without specific effort. If you know why you are doing it and if you enjoy it, you will take the time to do it, and you will do it well. And if you don't like it anymore or get bored, then finish your commitments and discontinue that activity. Of course, I should emphasize here that you have to finish your commitments first (see teamwork comments above)!

I hope I managed to illustrate that getting involved in your scientific community is not only extremely rewarding for you, but also possible for everybody, and that simple rules can help you balance your activities. There is a lot to do, various tasks for various people and at different levels of involvement. Every experience is of course different, and I would be glad to hear about your experience, should it be similar or very different. It is possible that you will have a bad experience or that something you try will not work out. In that case, don't be discouraged and try something else. Your experience can also simply be different from what you were expecting, but in the end, it is always a good experience. After all, experience is what you get when you didn't get what you wanted.

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Editorial

Ten Simple Rules for Teaching Bioinformatics at the High School Level

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Given the availability of free, online genomic databases and tools for the analysis of biological data, it is now feasible to teach bioinformatics in the high school classroom [1]. There are a number of reasons why it is appropriate and desirable to introduce bioinformatics at the high school level. Students can engage in inquiry-based activities that involve approaching real-world problems using 21st century skills, while being tailored to high school biology frameworks. Many tools, such as 3-D protein visualization software, allow for differentiated and highly interactive instruction. The foremost reason may be that students can develop a research toolkit that they will be able to use subsequently during college and beyond.

As a high school science teacher for the past 23 years, I (DF) have had the opportunity to incorporate bioinformatics into my courses to enrich the teaching of concepts of molecular biology, human biology, genetics, and evolution, providing increased opportunities for effective differentiated instruction and individual student research. This past experience has inspired the creation of this set of Ten Simple Rules.

It is important to distinguish between curricula designed to teach the fundamentals of bioinformatics and those that utilize bioinformatics as a teaching tool. Examples of both types of successful teaching can be found in Text S1, Text S2, and Text S3.

Rule 1: Keep It Simple

Set one, or a very few, objectives for each activity. Begin with a few, limited, straightforward goals. For example, an activity may require students to find a limited set of specific information in a GenBank file, such as the coding sequence for a gene, and print it out in FASTA format. You can link these objectives to other, more complicated, concepts in later lessons.

An activity will be more effective if extraneous information is kept to a minimum. The output provided to the students is likely to contain too much information for them to digest during one lesson. Focus on one or a few items.

Rule 2: Familiarity: Use Activities to Explore Examples That Are Familiar to Students

Familiarity breeds relevance. Much of the information presented to students will be new to them. It will make it easier to understand new concepts or information if they are linked to something that is already familiar to them. High school students are particularly interested in topics that they can relate to their immediate personal or social lives. Choose genes, proteins, or processes that relate to disease, development, or other aspects of human physiology and behavior. Obesity, diabetes, and developmental disorders are some examples that have worked well.

Rule 3: Link Activities to Preexisting Science Curricula

Bioinformatics exercises are more likely to be used if they are related to the curriculum that is already being taught. In a biology class, a lesson using 3-D protein models is more likely to be utilized if the proteins studied relate to concepts in the curriculum. For example, analysis of hemoglobin structure can be part of units on the circulatory system and genetics (sickle cell disease). The use of 3-D models can be used to help introduce students to structure–function relationships in proteins. Students can utilize 3-D protein models to compare the structures of proteins with very different functions, such as collagen, the estrogen receptor, and alpha amylase.

Rule 4: Develop Activities That Build on Each Other

More complex tasks and skills can be done successfully if they are broken down into small pieces that are taught separately and then combined in a stepwise fashion. Students can focus on learning one skill or concept at a time.

Rule 5: Use Activities to Build Skills and to Provide Information through Inquiry-Based Research

Students learn best when the work has meaning and when they are actively pursuing a goal. For example, a student who was asked to find the mRNA sequence for the gene involved in a disease that she was researching was wondering why there were several mRNA sequences for what she thought was a single gene. After an explanation of alternative transcripts and the roles of introns and exons in generating these transcripts, she was excited about her "discovery" and proceeded to explain this to her classmate/friend. She found the concept of RNA editing to be fairly easy because she actively discovered the process as part of her research.

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Rule 6: Provide Opportunities for Individualization

Students will often become more involved if they feel a sense of ownership for their work. Have individual students, or student groups, each research their own gene or protein. For example, each student in a class can be asked to identify the gene and protein associated with a unique genetic disorder. Make sure that the level of difficulty is appropriate for the level and age of the students.

Rule 7: Address Multiple Learning Styles

Student abilities and learning styles will vary among the class. Make use of the multiple ways that information is presented. For example, the output of BLAST makes use of a colorful graphical interface, a "hit list" in chart format, and sequence alignments. Using all of these will help students to understand a BLAST output.

Rule 8: Empower Students

Students like solving problems and discovering new information. Allow students to discover the concept or information that you want them to learn. This plays to a real strength of bioinformatics as a teaching tool. Set up activities so that students can follow up and extend their knowledge on their own, using the skills that they have developed.

Rule 9: Model Processes Using Pen and Paper before Using the Computer

Computers can handle large amounts of data and make complex manipulation of this data in a short period of time—that's why we use them in bioinformatics. However, this can often hide the processes from the students. Have the students run through a simplified mock-up of the data analysis using pencil and paper. For example, have them compare protein sequences and come up with a "score" of relatedness before using a program, such as BLAST (through the NCBI website). Have them find and highlight appropriate data in a printed form of a BLAST readout before they analyze a BLAST readout online by themselves.

Rule 10: Produce a Product

Have the students use the results of their activity to produce a "product" they can present to the class. If they are researching the structure and function of a protein, have them design a product that uses this protein. For example, in researching leptin they can design an obesity pill.

Supporting Information

Text S1 Examples of model curriculum. Here we provide example curriculum for two types of courses for secondary school students. One is for bioinformatics activities to incorporate in an introductory biology course. The second is for a course "Models for Disease" and is offered to Accelerated/Honors level students after completing a first course in biology.
(DOC)

Text S2 Example term project for "Models of Disease" class. For the "Model for Disease" course, students are required to complete a term project that uses bioinformatics tools to study a disease. Here we provide an example presentation given by a student based on their term project.
(PDF)

Text S3 Tips for developing curriculum. The materials presented here were also presented as part of a tutorial "Teaching Bioinformatics in High School Biology Courses" held at the International Society for Computational Biology's annual meeting (ISMB) held in Boston, Massachusetts, in July of 2010.
(PDF)

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Editorial

Ten Simple Rules for Developing a Short Bioinformatics Training Course

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Introduction

This paper considers what makes a short course in bioinformatics successful. In today's research environment, exposure to bioinformatics training is something that anyone embarking on life sciences research is likely to need at some point. Furthermore, as research technologies evolve, this need will continue to grow. In fact, as a consequence of the introduction of high-throughput technologies, there has already been an increase in demand for training relating to the use of computational resources and tools designed for high-throughput data storage, retrieval, and analysis. Biologists and computational scientists alike are seeking postgraduate learning opportunities in various bioinformatics topics that meet the needs and time restrictions of their schedules. Short, intensive bioinformatics courses (typically from a couple of days to a week in length, and covering a variety of topics) are available throughout the world, and more continue to be developed to meet the growing training needs. The challenges, however, when planning, organising, and delivering such courses, are not trivial [1], especially considering the heterogeneous backgrounds of participants. Here, we address such challenges and present a consensus of rules derived from the shared expertise of several bioinformatics trainers. While the rules apply broadly to bioinformatics training, aspects addressing specific audiences are also discussed in order to make these rules pragmatic and applicable to a wide range of readers. Delivering bioinformatics training is both crucial to facilitate the use of, and to exploit the investment in, bioinformatics tools and resources, and an excellent opportunity to solicit user evaluation and feedback to improve them. One point of crucial interest to the training course community concerns material preparation and distribution. Preparing effective materials (slides, notes, references, etc.) entails a huge effort that would be enormously facilitated if course developers could start from a body of available materials, for example if they could gain access to repositories of materials deposited by trainers of other courses. This was one of the reasons motivating the Bioinformatics Training Network (BTN) to set up the BTN website (http://www.biotnet.org/), which has been planned as a vessel for the training community to share and disseminate course information and materials. Course developers are warmly welcome to subscribe to the site and make available their materials to the community [2].

Rule 1: Set Practical and Realistic Expectations

It is critical to explicitly identify the training objectives and expected outcomes from the outset. Begin by devising the title of your course and specifying the target audience (e.g., laboratory biologists, computational scientists). This information is not only useful for trainers to help appropriately focus and weight the contents of their training sessions, but is also vital for participants. By explicitly stating the course objectives up front, trainees are better oriented to the expected outcomes and are more likely to be satisfied with the course. As most training sessions are based on slide presentations, dedicate at least one slide (preferably, while providing the session overview) to the learning objectives, and mention how these will be achieved, using specific examples whenever possible; if appropriate, also mention how the knowledge gained and skill set(s) will be useful for trainees' work environments. Stating what participants will not learn to do (e.g., to avoid over-estimation of the depth of analysis that can be achieved in a short course) is also important for tempering their expectations.

Rule 2: Verify That Trainees' Expectations Match Course Scope

Verify that trainees' expectations match what will be delivered. The most effective mechanism to ensure that expectations are well matched is to collect information from trainees prior to the training session itself (e.g., via a questionnaire), or by discussions with trainees at the start of the course. Obtaining such information early on allows time to alter course materials to better meet participant expectations, for example by adjusting case studies and

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examples to reflect the audience's interests. Furthermore, this will make you aware of the trainees' different backgrounds. Read, or listen to, and evaluate all responses, both to discern whether the course content matches participant expectations and to learn what the trainees' needs are. Such information will also allow you to detect clusters of trainees: e.g., those working with a particular model organism, those more interested in DNA than in proteins, or more plant than animal scientists. Useful information to collect includes their research backgrounds and computational skill sets, their current projects relevant to the course, and their expectations of the training (e.g., what reasons led them to apply for this particular course?). Also solicit information from trainees about the biological problems they wish to solve by participating in the course.

Rule 3: Plan Exercises and Activities and Test Resources before Delivery

Plan the course in independent units/modules, each with an introduction, set of aims, list of actions, and potential difficulties. When a new module is introduced, recall the achievements of the previous module, and state what tasks participants will be able to additionally accomplish at the end of the new module.

If you, the trainer, are also responsible for the resource/tool being presented, you are likely to be able to handle unexpected queries or problems. However, many trainers deliver sessions on resources/tools built and maintained somewhere else by someone else, using someone else's data. Regardless, always prepare an alternative plan in anticipation of unforeseen difficulties. For example, at short notice, you might not be able to use live queries, so ensure that you have sufficient back-up material (e.g., animations, videos, etc.) to allow you nevertheless to deliver your training session effectively.

To appear as prepared and experienced as possible, try your practical exercises beforehand. In cases where the query or task required to a bioinformatics server takes a long time, or is too demanding on the service provider, either begin with smaller query datasets, or provide the task results after trainees have prepared the query set-up, so that they still gain the experience of performing the task and class time is used more efficiently. It is important to note that some service providers will often hold query results for 48 hours.

Rule 4: Ensure Computational Equipment Preparedness and Hands-On Support Availability

Ensure (or rather, insist) that workstations (Linux, Mac, or PC) have all the necessary software installed to allow trainees to complete the course. Make sure that the venue provides each trainee (or, at most, each pair of trainees) with one computer. Where trainees are required to bring their own workstation (e.g., laptop), provide enough instruction and test commands to ensure that software and dependencies have been properly set up ahead of time. Request that a system support technologist be available, and in the room, when starting your sessions, to ensure the functionality of the classroom workstations and/or of the participants' personal computers.

Do not underestimate the trainer/trainee ratio, especially in consideration of the trainees' diverse backgrounds. Be prepared to provide extra hands-on support while trainees become familiar with new interfaces, tools, and resources. Such support may be provided by trainers of other modules, tutorial assistants, past trainees, or even current trainees who are familiar with the tool/resource basics.

Rule 5: Use the Dynamic World of Bioinformatics Resources and Tools as a Learning Opportunity

Provide time references for the information you deliver, as bioinformatics resources and tools, and stored data, evolve continuously. Place emphasis on the "official" sites, as these are most likely to remain stable reference points for trainees. When creating your materials and exercises, as much as possible, avoid screen-shots, as these date quickly—otherwise, you risk spending substantial amounts of time updating outdated slides rather than concentrating on developing suitable case studies and examples relevant to your audience. Describe the essence of data that can be retrieved from a particular resource and the principles governing a tool, rather than sticking to specific releases, web interfaces, or, for example, to tables of ranked results, which are likely to differ from day to day, as new data become available in the databases. Take into account that new data may have been added to the databases you are planning to use, and hence the outputs of the queries might be different from those you planned to demonstrate. As this occurrence is actually an integral part of bioinformatics, this can be beneficial for trainees to witness—you might even want to explore such situations extensively, to convey the idea that resources and tools are dynamic.

Rule 6: Balance Concepts with Practical Outcomes

Bioinformatics training encompasses a vast amount of learned skills. Acquiring these skills is a bit like learning to ride a bicycle, where it is best to just start pedalling, because watching others will not help you learn the process! Of course, it is important to provide trainees with the fundamental concepts and theoretical background to ensure that they can use bioinformatics tools and resources meaningfully. Nevertheless, it is a good rule to provide a balance between the theoretical/technical and contextual aspects. For example, many trainees may not value information on flat-files, relational schemas, APIs, and web services, but will be more concerned about knowing which tools and resources to use for their specific needs, and why, and how to interpret their outputs (just as the average cyclist is not interested in the internal workings of the gearbox, as long as they know how and when to shift gear!). Discuss the limitations of the methods without getting carried away by the intricacies of the algorithms or the minutiae of a tool's capabilities. Ensure that you cover not only those questions that bioinformatics approaches can answer, but also the limitations of bioinformatics, explicitly illustrating examples that cannot be answered.

Avoid long sessions of browsing around web interfaces or showing one screenshot after another. Trainees will be eager to try tools themselves and will benefit far more from a well-planned session, with adequate time allocated to an exercise or simple exploration, than from merely watching someone else explore for them. When giving a demonstration, try to get participants to follow along with you. To compensate for the likely diversity in speed and computer-ease of your audience, when possible, pair trainees of different backgrounds together and progress activities at a speed that will allow all trainees to keep pace. Once you have completed a task, confirm that everyone has achieved the result, and recapitulate the scope of the actions to reinforce the meaning and significance of the session. If you allow trainees to work by themselves on specific tasks, conclude with what you expected them to have achieved and how! Also consider providing this summary of steps and expected outcomes in an electronic/

paper version as an addendum, as trainees might want, and would certainly benefit from being able, to review the task again, on their own time. Furthermore, trainees will often be eager to share what they have learnt when they return to their work environments, so having a set of good course manuals/practical exercises is essential to enable them to do so. Absolutely avoid spending 80% of the session talking and then rushing through the last 20% of the practical aspects. Moreover, try to avoid telling trainees to finish later (on their own) whatever they did not complete, as they will probably not do so, will feel resentful because what they really wanted to do was not done and, more importantly, they will have lost the important recap and reinforcement that you can provide.

Rule 7: Reinforce Learning with Contextual and ''Real World Experience'' Examples

Wherever possible, provide appropriate biological context: examples without relevant context lack meaning and fail to engage trainees. After introducing a new concept, allow time to put the concept immediately into action. Begin hands-on exercises with a short worked example where everyone can complete contextual learning on a common dataset. Follow this with time for further exploration: here, you might either provide a second dataset or, if relevant or practicable, invite trainees to use their own. If appropriate, illustrate examples taken from your real world research experience. For instance, outline biological problems that you tackled with bioinformatics and describe resources and tools that you adopted to solve them and to achieve your findings and how.

Rule 8: Ensure the Methods/Tools Have Relevance to the Trainee Experience and Scientific Research Needs

Design your materials such that the examples you provide illustrate the concepts you wish to convey and, at the same time, are relevant to the research interests of at least some of the trainees. Whenever prior information about trainees' interests is available, use it. Appreciate that a plant biologist will not have a need for human-centric examples, nor will they find them comparable. The more relevant you make the examples for the trainees, the more likely they are to retain their interest and develop their skills! Furthermore, encourage trainees to explore the tools and resources presented during the course not only with the carefully prepared examples provided, but also from the perspective of their own research interests: nothing motivates as much as the need to solve one's own problems!

The use of tools and resources from the perspective of personal research interests, will lead new users to take a fresh critical look at them. From this perspective, trainees might be able to provide a special assessment of the tools and resources introduced in the course which would be different and complementary to the one that experienced users can provide. Trainers can gain an understanding of how easy (or hard) exploring web interfaces or programmatically access and parse resources is, and specific comments on what is intuitive or not to trainees can be captured informally or formally (e.g., through surveys). In this regard, you may explain to trainees that evaluation and feedback collected during the actual training course or in a final feedback survey can aid significantly to improve bioinformatics resources.

Rule 9: Allow for Interactivity and Provide Time for Reflection, Individual Analysis, and Exploration

Ensure interactivity and time for reflection. Provide time for trainees to acquaint themselves with the interfaces of the tools/resources, and to understand their contents: allowing trainees to explore a tool or resource on their own tends to promote greater retention of concepts.

Schedule 10–15 minutes at the end of each module to review the presented concepts, and to stimulate questions from the trainees, who will probably have only just started processing the information.

Do not simply rely on a set of slides and step-by-step tutorials to teach concepts. Make use of flip-charts to brainstorm together, asking trainees for ideas and alternative ways to resolve particular biological questions. Group sessions like this, where trainees are encouraged to share their thoughts and views with the whole class, can help both to identify common issues and aspects to be explored, and to highlight any trainee limitations and/or mismatched expectations. Moreover, incorporating such group discussions directly into training sessions can often help to instil a greater level of understanding than when trainees are left to passively explore set examples (or to copy and paste scripts with no explanation of what these might achieve). Exploit such brainstorming sessions to demonstrate how bioinformatics tools and resources can help to address, and sometimes solve, complex problems.

Depending on the time available, include quizzes and/or problem-solving tasks and open discussion sessions in which participants can reflect on the skills they've learned and how these might be used to address questions of interest to them.

Provide trainees (perhaps in pairs or groups) with a brief set of questions prior to, and after, the training course. Questions that probe their knowledge and understanding of bioinformatics are useful both for trainers (to verify that the course has been pitched correctly and to establish what knowledge has been gained) and for trainees. Furthermore, by asking trainees to think about, and answer, a series of course-relevant questions, you ensure adequate time for concept and content digestion and reflection.

Rule 10: Encourage Independent Thinking and Problem Solving

Finally, teach to fish rather than give fish! In other words, try to develop independent thinking rather than simply spoon-feeding trainees with slides and step-by-step tutorials: it is more important to learn how to tackle research questions with bioinformatics, and to know where/how to search for solutions, than it is to learn about the minutiae of every available tool and resource.

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