Making the Right Moves

A Practical Guide to Scientific Management for Postdocs and New Faculty

Burroughs Wellcome Fund
Howard Hughes Medical Institute
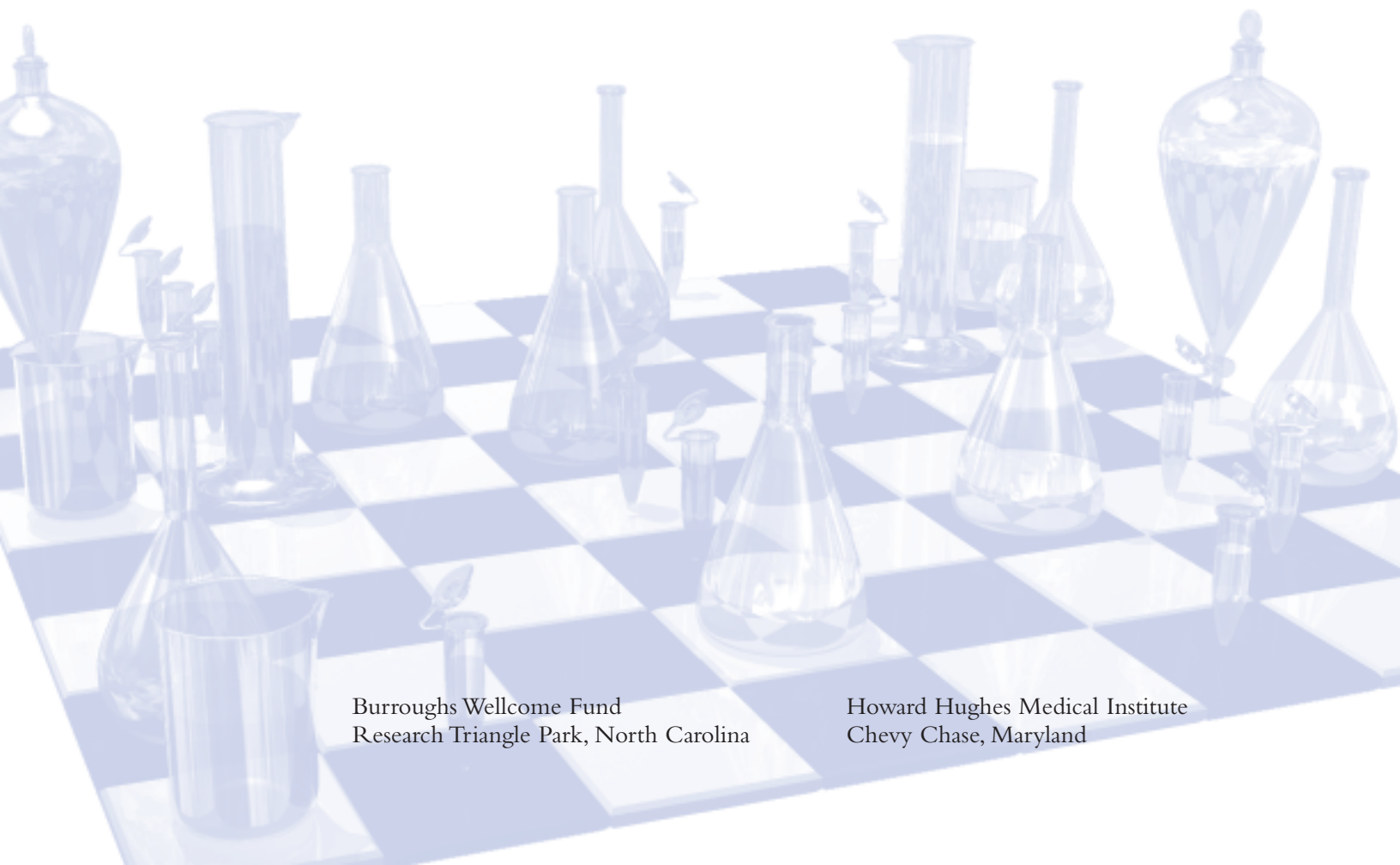
Second Edition

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A Practical Guide to Scientific Management for Postdocs and New Faculty

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Based on the BWF-HHMI
Course in Scientific Management for the
Beginning Academic Investigator

Contents

Preface

The Burroughs Wellcome Fund (BWF) and the Howard Hughes Medical Institute (HHMI) have similar missions—to advance medical science by funding scientific research and education. In July 2002, the two organizations entered into a unique collaboration to further advance these goals by offering a course in laboratory leadership and management at HHMI headquarters in Chevy Chase, Maryland.

The idea for the course grew out of feedback that BWF and HHMI staff had solicited over the years from talented young biomedical scientists who had received research training or career development grants from the organizations. These beginning investigators described the challenges they faced in having to fulfill their research, teaching, administrative, and clinical responsibilities while simultaneously being expected to obtain grant support, publish, hire staff, and keep their labs running smoothly—all without formal management training. Their comments suggested that the grantees might have avoided costly mistakes and made better progress if they had learned to be managers as well as researchers before establishing their own laboratories.

The course in scientific management, which focused on these competencies, received an exceptionally enthusiastic response. In the postcourse focus groups and surveys, participants said that a manual based on the course would be a valuable reference for them and for colleagues who could not attend the course. The resulting manual, *Making the Right Moves*, first published in 2004, was, like the course, a success. Since its publication, 15,000 copies of the book have been distributed to individual scientists and professional societies and many more copies have been downloaded as a PDF version available at *http://www.hhmi.org/labmanagement*. In June 2005, BWF and HHMI organized a second iteration of the course, which included new sessions, and revised the manual to reflect the new material. This second edition of the manual contains one new chapter, "Teaching and Course Design," and substantially revised chapters, "Laboratory Leadership in Science" and "Project Management." All other chapters were revised and updated with additional information presented at the 2005 course.

As a companion to this book, BWF and HHMI have also developed a how-to guide for organizing training programs focused on laboratory leadership and management. The guide is intended to encourage universities, professional societies, postdoctoral associations, and other organizations to develop these types of courses for their constituents. BWF and HHMI believe that training in scientific management should be made available to all researchers early in their careers.

Just like the first edition, the second edition of *Making the Right Moves* is intended for laboratory-based biomedical scientists just starting out—advanced postdoctoral fellows ready to enter the academic job market and new faculty members in research universities and medical schools. Much of the material, however, is also relevant to scientists pursuing nonacademic career paths. The manual is available on the Web as a PDF; a hard copy may be requested from HHMI. Academic organizations and institutions are free to distribute copies of the book, or sections of it, for educational purposes.

The purpose of the manual is to alert beginning scientists to the importance of the leadership and managerial aspects of their new (or soon-to-be-acquired) jobs and to give them practical information that will help them succeed as planners and managers of research programs. Not only will the researchers benefit, but the scientific enterprise will benefit as well.

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Acknowledgments

Introduction

You are now a fully trained biomedical research scientist. You have earned a Ph.D. or an M.D. or both and have spent several years as a postdoctoral fellow learning the ropes of your specialty. You have the credentials you need for a career as an academic researcher. But as you establish your own laboratory and build your research program, you are becoming aware that research skills are only part—albeit a critical part—of what you need to succeed.

In your first few years as a tenure-track faculty scientist, you will be asked to balance multiple new demands on top of your research, including teaching, administrative tasks, and perhaps clinical responsibilities. At the same time, you will be expected to hire staff and establish a laboratory, plan a coherent research program, obtain grant funding, and publish in the top journals. Meanwhile, your tenure clock will be ticking, placing you under enormous pressure to produce. You need special skills to meet all these expectations—a mixed bag of competencies that can be loosely characterized as "scientific management" skills. It is unlikely that you have received explicit instruction in any of these skills in graduate or medical school or during your postdoctoral studies. Like most beginning investigators, you probably were only able to learn a bit through trial and error or by watching your teachers and talking to your advisers, mentors, and fellow students.

> *Why do we need something like a lab management course? Biomedical research today is a complex enterprise that spans multiple biological levels, requires a variety of equipment and staff, and demands success with limited funds. Each one of you is really an entrepreneur running your own new small business.*
>
> —Enriqueta Bond, BWF

This manual provides an outline for filling this educational gap. The content of the first edition of this book, published in 2004, was based on the "Course in Scientific Management for the Beginning Academic Investigator," held at Howard Hughes Medical Institute (HHMI) headquarters in July 2002. The course was developed and sponsored by the Burroughs Wellcome Fund (BWF) and HHMI for selected BWF and HHMI grantees. This revised version of the manual incorporates new information from the second BWF-HHMI course held at HHMI in June 2005. The chapters were developed from the course presentations and panel discussions, handouts from presenters, the question-and-answer sessions, feedback from course participants, and subsequent interviews with the presenters and other scientists. In addition, more information, particularly relevant to physician-scientists, was added to each chapter. Content was also drawn from many of the resources listed at the end of each chapter. Each chapter was reviewed by the session speaker(s), course developers, and other BWF and HHMI staff.

Although *Making the Right Moves* is directed to laboratory-based academic scientists, much of the material would also be of use to beginning investigators in government and industry labs. The first chapter, "Obtaining and Negotiating a Faculty Position," offers tips on finding and negotiating terms for a faculty position and outlines the expectations of a faculty job. The next chapter, "Understanding University Structure and Planning for Tenure," takes a look at the typical decision-making hierarchy of a research university and an academic health center, discusses your professional responsibilities outside the laboratory, introduces some of the academic offices with which you will interact and the resources available to support your research, and outlines the requirements for obtaining tenure.

Two chapters deal with people skills. "Laboratory Leadership in Science" summarizes the role of the head of the laboratory in leading, motivating, and managing members of a lab. "Mentoring and Being Mentored" explores what it means to be a mentor, particularly as a strategy for facilitating learning and training new scientists. It includes approaches to help you be an effective mentor and offers advice on how to obtain the mentoring you need.

"Staffing Your Laboratory" provides pointers on recruiting a team of people who will contribute to the success of your lab. It also discusses what to do if you have to let someone go. Several chapters offer information about time management, project management, and data management. "Getting Funded" and "Getting Published and Increasing Your Visibility" discuss these challenging tasks in the competitive environment of biomedical research. "Setting Up Collaborations" and "Understanding Technology Transfer" are particularly relevant at a time when research projects often involve scientists in different departments and different universities and when research findings are often shared with industry and government.

New to this version of the book is the chapter "Teaching and Course Design," which offers tips on how to design a course, how to deliver lessons that engage students, and how to keep teaching responsibilities from engulfing your time.

Given time and space constraints, some topics, such as lab safety, scientific writing, public speaking, communicating science to the public, and science policy, were not covered in the BWF-HHMI courses or in this manual. This information is typically taught at most universities or is available from other sources (e.g., HHMI has published several videos on laboratory safety, available at no charge from HHMI's online catalog at *http://www.hhmi.org/catalog*).

The manual is not meant to be a comprehensive reference text. It is designed to highlight key points about managing scientific research operations that are not readily available in print elsewhere. The manual is likewise not meant to be prescriptive. It is a collection of opinions, experiences, and tips from established scientists and professionals. A complementary publication, *Training Scientists to Make the Right Moves: A Practical Guide to Developing Programs in Scientific Management*, serves as a resource for organizations that are developing their own courses in scientific management.

You are encouraged to supplement the information in this book with resources from postdoctoral or professional associations and Web resources, as well as the books and articles mentioned in each chapter. You are also encouraged to discuss ideas in the book with colleagues, mentors, and advisers and to suggest that they organize similar courses at your own institution.
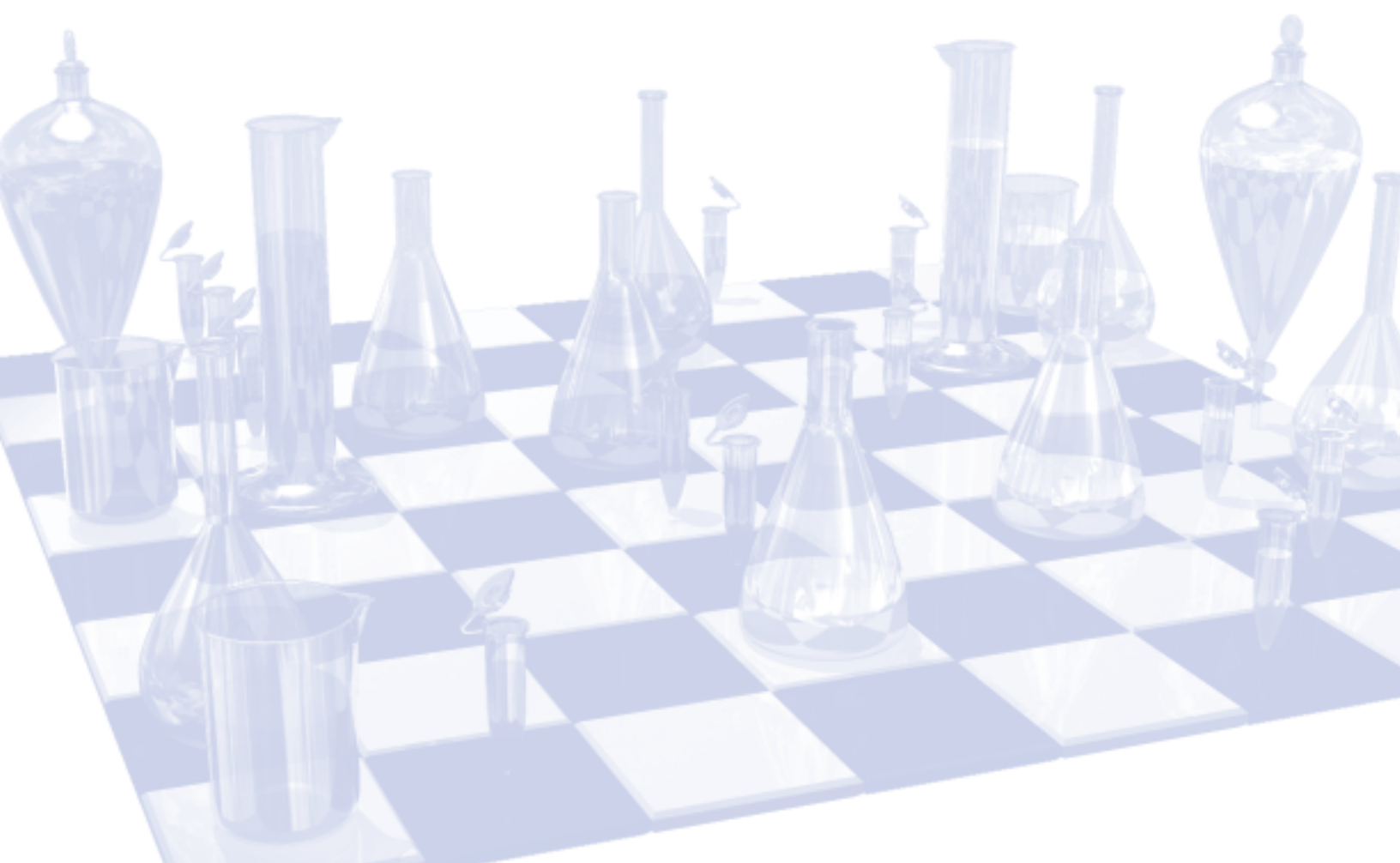
Chapter 1

OBTAINING AND NEGOTIATING A FACULTY POSITION

As you complete your postdoctoral training, you are probably starting to think about the next step in your research career. For some of you, this may mean a position as an investigator in an industry or government laboratory. For others, this may mean a faculty position at a university or medical center. If you pursue the latter, you will have to decide whether a tenured or nontenured position is better suited to your personal goals and ambitions. Although all these career options are rewarding, this chapter focuses on the tenure-track faculty appointment.

As you embark on your search, you will face a series of challenging questions:

◆ What do I want and need from my job?

◆ How do I go about finding a job?

◆ How can I ensure that my achievements and capabilities will be recognized?

◆ How will I choose among the offers I receive?

◆ How can I ensure that the resources I need to launch my career are included in the job package?

There are no universally right answers to these questions, but there are well-tested strategies for finding and obtaining the right academic appointment and for obtaining tenure. This chapter discusses some of them.

THE JOB SEARCH

Once you decide to launch your search, make it a concentrated effort. Ideally, doing so will bring multiple offers your way at about the same time. Making the job hunt a flat-out effort also makes the labor-intensive process of gathering credentials and references much more worthwhile. Keep in mind that most academic positions are advertised in the fall, with the assumption that the job will start in summer or fall of the following year.

Knowing What You Want

Your chances of finding the right job will be greater if you have your own needs and wants firmly in mind. For example, consider the following questions:

◆ Do you need to be working at a top-rated institution, or would a less-intense atmosphere be acceptable or even preferable, given your talents and ambitions?

◆ Do you want to devote yourself exclusively to research, or would you prefer some combination of research and teaching or clinical practice?

◆ Do you want or need to be in a particular area of the country? Do you prefer an urban, rural, or suburban location?

◆ Will personal responsibilities, or your spouse's or partner's professional needs, set limits on your search?

◆ If you are a physician-scientist, will you want to see patients and how much time will you want to devote to research versus clinical practice?

Learning What Is Out There

Use all available formal and informal sources of information. Formal sources of information include the following:

◆ Job announcement letters sent to your department

◆ Announcements (print and online) in major scientific journals such as *Cell*, *Science*, and *Nature* and in publications devoted to your subspecialty

◆ Web sites of academic institutions

◆ Employment bulletins published by professional associations

◆ Mail list servers for postdoctoral fellows

Informal sources can be even more valuable—for example, the supervisor of your postdoctoral research; other scientists with whom you have a relationship, especially those with whom you have collaborated; and your peers. So, get the word out that you are looking.

A Few Career-Related Web Sites for Scientists

Science magazine's ScienceCareers.org Web site contains a Career Development resource for postdocs and beginning faculty (*http://sciencecareers.sciencemag.org*).

The Chronicle of Higher Education's online newsletter "Career Network" has career news and advice and publishes new scientific faculty and research jobs every day (*http://chronicle.com/jobs*).

The University of Washington's *Re-envisioning the Ph.D.* provides Web resources related to job hunting for doctoral students, postdocs, and academics (*http://www.grad.washington.edu/envision*).

Narrowing Your Search

Measure each job opportunity against your list of priorities. Find out about

◆   The institution's mission, values, political and social climate, and quality (e.g., national or regional ranking)

◆   The department's mission, research activities, curriculum, and collegial atmosphere

◆   The parameters and expectations of the position, including whether it is tenure track

◆   Faculty policies regarding parental leave and tenure clock extension

There's no easy way to tell how many positions to apply for. Remember, though, job hunting is not wasted time; the process has valuable spin-offs. For example, you will get a chance to make presentations about your work. Your ideas are sharpened in the process, and the research itself benefits. You are practicing skills you will use throughout your career. You also get better at the job-hunting process as you go along. Your self-confidence builds, and your sense of what you want develops as you are introduced to various research environments.

However, don't apply for a job that you are clearly not qualified for or that really does not interest you. You don't want to waste people's time and perhaps damage your own credibility.

What Is Tenure Track?

Tenure is not given immediately to new faculty. Instead, jobs are designated as eligible for tenure, or "tenure track." A tenure-track position is one that leads to a permanent professorial appointment. In most institutions, tenure confers virtual lifetime job security because a tenured professor cannot be fired, except for certain limited causes, such as gross misconduct or neglect of duty. For many basic sciences departments, tenure means full salary support even if grants dry up. In the clinical sciences, because clinicians have a second source of salary support other than the university, tenure may not imply full salary support. Keep in mind that, from the perspective of the institution, tenure is a financial commitment to you. Being offered a nontenure position is not necessarily a reflection of the institution's assessment of your worth, but rather an assessment of whether the position is one that they can commit to supporting, even if your grant funds dry up.

Typically, a faculty member hired in a tenure-track position will work for approximately five years before a formal decision is made on whether tenure will be granted. If tenure is not granted, the investigator is typically asked to leave so that someone else can fill the tenure-track spot.

Non-tenure-track positions are often characterized by lower salaries and high teaching loads. But on the upside, some individuals choose them because they provide greater choice in terms of geographic location (as these posts are less competitive) and greater flexibility in career choices. (Also see chapter 2, "Understanding University Structure and Planning for Tenure.")

THE JOB APPLICATION

Once you have found one or several positions that you would like to apply for, you want your application to stand out sufficiently so that you will be invited for an interview. Here are some guidelines.

Making a Good First Impression

Your application is likely to be one of hundreds that an overworked search committee must sift through. Follow the application instructions, and make sure your application is concise and free of factual, grammatical, and spelling errors. You don't want it eliminated at the outset because it makes a bad impression.

Get your application in on time. However, if you learn about the position after the application deadline has passed, still send in your application; many departments are willing to consider late applications.

> *While a nicely prepared application will obviously not get you a job, a poorly prepared one makes a bad impression no matter how many papers you have published.*
>
> —Johannes Walter, Harvard Medical School

Components of a Job Application

The cover letter. This letter, which should be limited to one page, is extremely important and should be written with great care. It should give the search committee a quick but informative picture of your background and interests relevant to the job. Include the following items in your letter:

◆ Brief self-introduction

◆ Statement specifying the position for which you are applying

◆ Statement about your research accomplishments, indicating why the work is novel and interesting

◆ Brief description of your research plans, indicating what is important or creative about what you propose

◆ Brief description of your teaching (or clinical) experience, if the position emphasizes these activities

◆ Any special circumstances you believe the committee should know about up front

The last item may be a difficult judgment call. It is hard to know whether to reveal information that could eliminate you as a candidate before you've even had an interview but that will need to be addressed should you receive an offer. The classic example of such a situation is that your spouse is also a scientist looking for a faculty appointment. If you decide not to mention such a circumstance in your cover letter, inform the search committee of your special needs early in the interview process.

You may also mention your references (included in your curriculum vitae, or CV) and describe how they know you.

The CV. This career summary should contain:

- Your name and address

- All higher education, with degrees obtained and dates

- All professional positions held, with dates and brief descriptions of the work performed

- Awards and honors, including pre- and postdoctoral fellowships

- Major sources of independent funding

- Publications

- Teaching experience, awards, and interests

- References, including names, titles, and addresses and other contact information

- Invited keynotes and presentations

- Board certifications and eligibility for physician-scientists

Two-Academic-Career Couples

"Partner hire" packages, in which a job is found for the accompanying spouse or partner, take considerable work. You should put this item on the table early in the interview process—certainly before you receive an offer. You will learn whether the university, and your prospective department, views two-career appointments positively or as a nuisance.

Highlight your name in bold type in your publications list. If you are listed as an equal author on a paper, use an asterisk next to your name and all other authors who are equal and note "*equal authorship" immediately below the relevant reference. *Do not rearrange the published order of authors to show that you have equal first authorship.* List manuscripts in preparation under a separate category. Indicate accompanying *News & Views* articles or other reviews of your publications. Do not include posters exhibited at scientific meetings.

The research proposal. This is the core of your application. It will describe your research plans to a search committee composed of people from several scientific areas outside your subspecialty.

Many successful applicants write two (or possibly three) research proposals, the first of which is closely related to their current postdoctoral work. The second and third proposals show the applicant's ability to think beyond his or her current work. These proposals are typically more creative and demonstrate a bit more risk. Include the following items in your proposals:

◆ A statement about the problem you intend to work on, indicating the key unanswered questions you will tackle. State how this research is expected to contribute to your general area.

◆ A description of your research plans. This section should comprise 50 to 70 percent of the proposal. Put forward three or four specific aims that address a range of fundamental questions within your discipline. Demonstrate that you have the necessary background to achieve what you propose. Be both creative and realistic.

◆ A few figures (perhaps one per proposal). These can help make your proposal more interesting to the search committee, which will be wading through perhaps hundreds of proposals from the other applicants. Remember, figures are most useful when they're embedded in the text and not tacked on at the end.

◆ A detailed description of your postdoctoral research, with an emphasis on what is novel and important and how it is the basis for your research proposal. Describe your predoctoral graduate research only if it is critical to your current interests. Make clear to the search committee that the work you are taking with you will not be in direct competition with your postdoc adviser.

◆ A list of references that includes your publications and manuscripts submitted or in press, as well as pertinent publications by others.

Reprints. Follow the directions for each application. Send along any important papers that are not yet published; otherwise, the committee will not have access to them.

Statement of teaching. If the job has a teaching component, add a separate section describing your interest in and approach to teaching and your experience.

Letters of recommendation. Depending on the application instructions, letters of recommendation can be included in the application package or submitted subsequently to the search committee. Typically, these letters are written by your graduate and postdoctoral advisers. It is also perfectly acceptable to submit one or two more references than the number asked for in the application. When you approach someone other than an adviser for a letter of recommendation, use the conversation as an opportunity to get a sense of how they judge your work. If you encounter any hesitation at all, or an indication that the person does not have time to write a letter or does not know you well enough to do so, ask others. You should ask someone

Question: What if I don't get along with my adviser?

Answer: If you do not have a good relationship with your adviser and cannot ask for a letter of recommendation, make sure you explain *why* in your cover letter. Be completely candid about the situation. Not having a recommendation from your adviser is a red flag to the search committee and will not be ignored. The committee may even contact your adviser anyway. A letter from another faculty member from the same institution may be critical in this case.

who really knows you and your work, not just someone with an important title.

Give those who are writing you a letter of recommendation plenty of time to prepare the letter. Give them your application package. If they suggest, prepare a draft of the letter of recommendation for them. Point out strengths you have that they may not be fully aware of. But be careful—do not appear to be dictating your letter to them. Provide them with stamped, addressed envelopes. Tell them when each letter to each of your potential employers will be needed, and then remind them until they send your letters. Check to verify that each letter has been received.

THE JOB INTERVIEW

$\mathbf{A}$ formal interview for a faculty position typically takes the form of a daylong or overnight visit to the campus. Normally, the institution inviting you for an interview pays your expenses for travel and accommodations. You can expect to meet with several faculty members, as well as others who may be asked to provide feedback about you to the search committee, and to give talks about your research. It will be your task to do the following:

◆ Convince the department that your work is exciting and that you will be a leader in your field.

◆ Convince each member of the department that you will be a good colleague.

◆ Find out if the institution and the department are right for you.

Be prepared for a demanding and exhausting experience. You will be on display at all stages of the visit, from the moment you are picked up at the airport until you are sent on your way again.

Advance Preparation

Come well prepared by doing the following before your visit:

◆ Organize the logistics of your trip, including travel tickets, hotel accommodations, arrangements for pick up, and the schedule of events on interview day. Be conservative about your estimates of travel time: You don't need the added stress of missing a connection and being late.

◆ Find out about the academic interests of the people you are likely to meet. Read a few of their papers or at least skim the abstracts. Be ready to ask them about their work. You can probably find this information on the department's Web site.

◆ Learn as much as possible about the institution and the surrounding area. Knowing something about the city or town will give you a starting point for small talk.

◆ Physician-scientists may meet with representatives of the clinical enterprise and should be prepared to talk about the business side of clinical medicine, including how they will meet their salary goals through clinical work. They should also be prepared to ask about what support staff will be available to them in the clinic.

Dress Code

Dress neatly and in keeping with scientific custom as you know it. Avoid dressing at a level of formality that will make you and your hosts uncomfortable.

Preparing Your Job Talk

During your interview visit, you will be asked to give a "job talk"—a formal presentation on your current research. A job talk generally lasts about an hour, including 10 to 15 minutes for questions. You have probably given this kind of talk before, and you know what works for you, but here are a few guidelines on how to prepare your talk.

First, write out the entire talk, thinking of your audience as you write. Remember, a talk is not presented in the same way as a scientific paper. You must get your main ideas across to listeners who have had little opportunity to study the details, as well as to those whose research interests and backgrounds are very different from yours. You can assume that your audience will be composed of intelligent people who are uninformed about your chosen scientific field. To help your audience follow your talk, divide it into several clear and concise sections, and give an overview of the talk at the beginning. At the end, restate your conclusions and offer an outline of your future research plans. At the outset or at the conclusion of your talk, include a brief statement acknowledging those who helped you in your research.

Next, translate your talk into a slide presentation. Most researchers use PowerPoint presentations to deliver their talks. Remember, however, to bring along a backup disk. Be sure to inform your hosts ahead of time about your audiovisual needs. Try to vary the design of your slides, alternating between text and figures. Resist the temptation to use only bulleted points, but also avoid long sentences. Be sure that your slides are readable and that the order of your slides matches your written presentation. (The American Society for Biochemistry and Molecular Biology and other professional societies publish guidelines for preparing these presentations.)

Finally, practice your talk in front of a mirror. Doing so allows you to time your presentation while getting used to the sound of your own voice. Keep repeating the talk until you can deliver it easily, using your slides as your only memory aid. If necessary, edit the talk down until it can be delivered comfortably within 50 minutes. Remember that a talk that is slightly too short is much better than one that is

too long. It may be better to focus on only one aspect of your research, so you can give sufficient detail within the time you have. Save the rest for the question-and-answer session.

When you feel comfortable giving your talk, enlist your adviser, your postdoctoral colleagues, and any graduate students you work with as an audience for a practice talk. Encourage them to ask questions and offer frank criticism. Ask them for suggestions to improve your PowerPoint slides, and leave enough time to edit your slides accordingly.

> *We always ask the administrative assistant how she was treated by the candidate, both on the phone prior to the visit and during the visit. This is always very illuminating. I think candidates need to pay attention to how they treat the staff.*
>
> —Ann Brown, Duke University School of Medicine

Delivering the Talk

Experienced speakers resort to a variety of techniques to control nervousness. Here are a few of them:

◆ Arrive early enough to set up equipment and become comfortable with the room. You may have to ask your host to get you to the room with enough time to prepare.

◆ Plant your feet firmly on the floor. Feeling balanced is important to your self-confidence.

◆ Know what you intend to do with your hands. A computer mouse and a pointer may be enough to keep you from fidgeting—but be careful not to play with either of them.

◆ The most nerve-wracking minutes are those just before you begin your lecture. Focus on your breathing—make deliberate every inhale and exhale, to control a rapid heart rate.

◆ Greet your audience and tell them you are glad to be with them. Make eye contact with a few audience members who seem eager to hear what you have to say. Then plunge in.

◆ Don't worry if some people nod off or seem uninterested; continue to give your talk as you practiced it, making eye contact with those who are listening closely.

◆ Let it show that you are excited about your work.

◆ Even though you may have done all the work presented, it is important to sound modest in your presentation. Begin by saying, "The work I will tell you about today was carried out while I was in the lab of X at University Y." Then, describe each slide in terms of "we."

◆ A good trick to avoid a discussion period with no discussion is to plant a seed in the audience during your talk to encourage questions later, for example, by saying "I don't have time to give you the details of that now but would be happy to talk about that during the discussion."

> *Some fraction of the audience is always asleep during any talk, no matter how exciting the subject. Find a few people who are listening attentively and give your talk to them.*
>
> —Johannes Walter, Harvard Medical School

Answering questions during a talk can be especially difficult. Several ways for handling this are noted here:

◆ Repeat the question for the audience. Then take your time answering. If you need to, buy some more time by asking for a restatement of the question. In a pinch, give an interpretation of what you think the questioner wants to know. Then give your best answer and stop. Rambling on only conveys uncertainty.

◆ It is okay to answer, "I don't know." But offer to follow up, and do so. It's a great opportunity to make contact with faculty after the interview.

◆ If questions are slow in coming, take the initiative by pointing out some aspect of your work that you passed over quickly but that you believe warrants the audience's attention. This gives you a chance to use some of the material you edited out of your talk. You may generate a whole new line of questioning. In case you need to go back through your slides to a particular one in order to clarify a point, arrange to have your computer presentation accessible during the discussion period.

◆ If challenged, listen to the criticism and give a judicious response. Don't become defensive. If the criticism seems unfair, stand your ground politely. You might suggest a follow-up discussion later.

Giving a Chalk Talk

During your interview visit, you will likely have an opportunity to give a less formal presentation—a chalk talk—during which you can offer detailed information about the direction of your future research. It should not be a polished slide presentation, but it should be prepared carefully.

Give a brief overview of your research agenda, including your short- and long-term objectives. Then state several specific problems you want to work on, and explain in detail how you plan to proceed. Be prepared to write on a white board and bring along an overhead or two of preliminary data that will demonstrate the feasibility of your plan. Show that you are familiar with the details of any new techniques you may need to master. Be sure to convey to your audience why the work is important and how you can make a difference to the field.

Expect to be interrupted. The chalk talk is a chance to show that you can think on your feet and that you will be an interactive research colleague.

Meeting Potential Colleagues

Meeting other faculty members. Typically, part of the interview process will include one-on-one conversations with members of the department. It is important to show interest in their work and ask lots of questions. Remember that faculty members are looking for a colleague who will benefit their own work, as well as someone who is a good scientist. In addition, assume that you will be taken out to dinner by some of the faculty. This is a chance for them to evaluate you as a future colleague and for you to determine whether you would enjoy working with them. Be yourself during these events.

Meeting with students, postdocs, residents, or other trainees. This is essential for someone who expects to conduct research in any department. A candidate should be concerned if a department doesn't offer ample opportunities (over lunch or in the lab) to meet with students and postdocs in the absence of faculty.

> *When you're talking to the faculty, it's important to appear interested in everybody's work. You don't have to be an expert on the topic. If you know something about it, it's good to chime in with a suggestion or a question. If you're clueless, it's fine to say, "This is really fascinating, but could you give me a bit more background?" It's also very important to give a dynamite seminar so that the people who didn't get a chance to meet with you privately will have a chance to hear about your work, how you express yourself, and what kind of a context you put your research in.*
>
> —Thomas Cech, HHMI

Concluding Your Visit

Typically, your visit will conclude with a conversation with the chair of the search committee, in which you might expect to learn when a decision will be reached. As soon as you return home, write a formal letter addressed to the chair of the committee, thanking everyone for their hospitality and reiterating your interest in the position. If during your one-on-one interviews, you have promised to share data, be sure to follow up on your commitment. Now it's time to play the waiting game because the committee will undoubtedly be charged with arranging interviews for several candidates.

Be sure to inform the search committee chair if you decide to take another job before the committee extends an offer to you or if for some other reason you decide to withdraw your candidacy.

NEGOTIATING YOUR POSITION

The chair of the search committee or the department chair has given you a tentative offer or at least let you know that you are the top candidate. You are now in a position of maximum strength for obtaining what you want. The search committee has invested time and effort in choosing you, and the last thing its members want is to come up empty or to have to start over. They have decided they want you and will be disappointed if you don't come, and they want you to be happy once you are on board.

Evaluating the Offer

Before making a decision, you will need to find out as much information as possible about the position. If you are not satisfied with some aspects of the offer, try to negotiate better terms. You will have to do the following:

◆ Learn the details of the offer.

◆ Reread the list of priorities you made at the outset of your search to evaluate how the job stacks up against that list.

◆ Calculate precisely what you are worth in salary and other benefits to determine whether the offer measures up. For example, can you afford to live in the community? Does the institution provide housing allowances or low-interest loans to help?

◆ Enumerate in detail the other resources you believe you need to succeed in your scientific career (decide what is absolutely necessary and what you can live without). In some cases, it may be satisfactory for the department to guarantee you access to shared equipment, rather than buying you your own.

◆ Make your wishes known to the institution representatives and engage them in the process of negotiating with you.

◆ Get everything spelled out in writing.

◆ For physicians in clinical departments, make sure the offer indicates the extent of clinical duties and clinical support (such as the availability of nursing staff and assistants to take telephone messages and refill prescriptions).

The search committee is your natural source for basic information about the terms of the appointment and about university-wide benefits and policies. Ask for a copy of the university's faculty handbook and any other personnel policy manuals. Read them over thoroughly, check them against the recommended standards of the American Association of University Professors (AAUP), and prepare a list of questions for the committee.

> *It is important to start thinking about the tenure process at the point of interviewing and negotiating for the right job. Ask what the rate of tenure is for the junior faculty at the institutions you are considering, what the general process is, pitfalls, and so on. Remember that the purpose of being an assistant professor is to become an associate professor, so make sure you educate yourself about what to expect before you make your choice.*
>
> —Matthew Redinbo, University of North Carolina–Chapel Hill

You may need to do some homework to rule out problems that may not be revealed in response to direct questions or that you simply cannot ask the search committee about. For example, it would be helpful to know whether the department has experienced internal personal conflicts recently, whether the university has financial problems, whether the chair is retiring or stepping down soon, and whether key faculty members are about to leave or retire. You also want to know whether people who have worked in the department have been happy, well supported, and successful. Use the grapevine: Call people you met during your interview visit, and talk with postdocs or others recently affiliated with your potential department and institution. Be discreet, but be straightforward. You don't want to be surprised.

When you are contacted with an offer, you might be asked for a second interview. This time, you will be able to ask more detailed questions about the position. You might also visit the human resources office, talk with key people in your prospective department, and have a preliminary look at available housing. A second interview visit is an excellent time to start the discussion about what you will need in terms of laboratory space, materials and equipment, and staff.

What You Need to Find Out

Here are some of the details that you will need to ask about.

The appointment. You need to know the following:

◆ Your job title and what it means

◆ The length of your initial contract

◆ The terms under which the contract will be renewed

Question: What if I'm offered an appointment to more than one department?

Answer: Insist on clarification in writing of where your "tenure home" will be, what the performance criteria for tenure will be, who will be making the tenure decision, the percentage of your salary paid by each department, where your office will be located, what your teaching responsibilities will be, and who will serve as your mentor. Seek advice from others who have worked in similar situations. For example, one experienced academic scientist cautions against accepting an appointment that is split 50-50 between departments.

Verify that you are indeed being offered a full-time tenure-track position. For example, several California schools have offered positions that appear to be full time yet are only half time or less than full time as far as a state-sponsored faculty position is concerned. In these cases, a faculty member is expected to rely on other funds for a significant part of salary and other support. You also need to find out about the process for obtaining tenure (see chapter 2, "Understanding University Structure and Planning for Tenure"). Research faculty appointments are often "at-will" appointments, offering no tenure protection if, for example, the position is eliminated or grant funding is lost.

The salary. You need to pin down the following:

◆ The amount of your base pay (this will determine the level of other benefits and future raises)

◆ Whether the salary is guaranteed, and, if so, for how long—in other words, you need to know whether part of your salary and other support must eventually be obtained from research grants or other nondepartmental or institutional sources

> *If you have a dual appointment, it's important to clarify which department will be paying the bulk of your salary, because that department will have the biggest right to your time. For example, if your secondary department wants you to increase your teaching load, you could request that they negotiate with your primary department to reduce the teaching load there in exchange for picking up more of your salary.*
>
> —Milton Datta, Emory University School of Medicine

◆   The department's history of salary increases

◆   Whether you will be paid on a 9-month or 12-month basis (if you are paid on a 9-month basis, find out whether your paychecks can be prorated over 12 months)

◆   If paid on a 9-month basis, does the institution allow you to pay yourself a summer salary from a research grant? Is there an institutional pool of money that will provide a summer salary for a year or two until you can obtain grant funding?

◆   Your institution's policies on outside consulting, including how much consulting is permitted, what approvals are required, and what limitations apply

Knowing what you are worth. There are many sources of information that you can use to evaluate your starting salary (see figure 1.1). Salaries differ widely depending on degree, geographic location, type of institution (public versus private), and scientific discipline. To evaluate the salary offered, you need comparative information on starting faculty salaries at the institution offering you the job and in your field elsewhere as well as on costs of living.

Figure 1.1. University starting salaries and start-up packages for junior faculty who received Burroughs Wellcome Trust Career Awards in Biomedical Sciences (CABS) and began faculty positions as tenure-track assistant professors in U.S. universities.

Faculty Appointments, 2004–2005*	
Ph.D.s (n = 21)	
Average 12-month salary	$92,632 ($73,000–$135,000)
Median 12-month salary	$89,333
Average start-up package (less salary)	$506,392
Median start-up package (less salary)	$675,000
Physician-Scientists (n = 11)	
Average 12-month salary	$127,315 ($93,000–$155,000)
Median 12-month salary	$125,500
Average start-up package (less salary)	$441,245
Median start-up package (less salary)	$480,000

*These data were obtained from accepted offers received by CABS awardees who moved from postdoctoral to tenure-track assistant professor faculty positions. The positions ranged across the basic biomedical sciences, public and private institutions, and U.S. geographic areas. Although the sample size is small, the data are consistent with those obtained from CABS awardees who have received faculty appointments since 1996.

Source: Rolly L. Simpson, BWF.

Try the following resources:

◆ The AAUP publishes an annual salary survey in the March-April issue of *Academe* (*http://www.aaup.org*).

◆ The American Chemical Society publishes a detailed annual salary survey, with data broken down by employment sector, geographic region, and professional specialty, in the magazine *Chemical & Engineering News* (*http://pubs.acs.org*).

◆ The Association of American Medical Colleges publishes an annual salary survey that contains data for professors at U.S. medical schools (*http://www.aamc.org*).

Other forms of compensation. Get the details of the following:

◆ Health coverage, life insurance, disability insurance, and retirement benefits

◆ Other family-related benefits, such as tuition support for family members and access to university recreational facilities

◆ Whether moving expenses will be paid

◆ Availability of a housing subsidy or at least assistance in obtaining housing

Start-up package. Find out what resources the university will make available to support your research until you can obtain grant support. Specifically, ask about office and lab space, equipment, computers and software, a technician and other support staff, the principal investigator's contributions to graduate student stipends, help in obtaining grants, and support for travel to conferences and meetings.

Service within the university. Ask how many committees and other projects you will be expected to become involved with.

Teaching responsibilities. Although rewarding, teaching can be the most time-consuming activity for new faculty. You will want a clear statement about the following:

◆ Your teaching load (the number of classes each term, typical enrollments, and levels and types of students)

◆ Teaching-related responsibilities (office hours, direction of student theses, advising students)

Hard Money Versus Soft Money

Hard money refers to any guaranteed funds that you receive from the university where you are employed. When you are offered a faculty position, you typically receive salary and start-up funds—hard money—to cover the costs of starting your laboratory during the first one or two years of your employment. After the start-up period ends, you may continue to receive hard money support for at least a portion of your salary and perhaps for a technician's salary. However, you will also need to obtain grant support (soft money) to pay for your research and, at some universities, all or part of your salary as well. Soft money therefore refers to funds that you receive from grants—for which you will most likely have to compete.

◆ Teaching-related responsibilities if you have an appointment in two differ-
ent departments or if you will be a member of one or more departmental
graduate faculty groups or of an interdepartmental graduate program

Ask for a reduction in teaching responsibilities if your appointment involves
heavy service responsibilities or if the position entails an appointment in two
departments.

Protected research time. Now is the time to maximize and codify in writing how
much protected time you will have for research. You need to clarify as much as
possible expectations and decrease, if necessary, the number of other obligations
you have. Once you have signed a contract, it will be hard to make changes.

Special Issues for Physician-Scientists

Negotiating Protected Research Time

If you are a physician-scientist, you will probably be expected to spend some time in income-generating
patient care. Be sure this requirement does not engulf your research time. You should negotiate a writ-
ten promise of a fixed percentage of protected time you will have for research—that is, a time when you
are not on call and are not responsible for seeing or following up on patients (although it might include
time for teaching or for administrative duties). In addition to being given a percentage of protected
research time, you may also want to ask for a concrete definition of your clinical obligations (e.g., a half-
day per week in the clinic or two weeks per year rounding on the inpatient service). The way the split
between patient care and research is implemented differs from institution to institution and from depart-
ment to department. For instance, individuals with a 50-50 split might have one month of clinical duty,
followed by one month of research time, or attend to clinical duties mornings and laboratory work
afternoons, or vice versa. While in theory it is possible to set up these parameters, they may play out dif-
ferently in reality. You can't necessarily stop treating a critical care patient because you have switched
back to a research month, and patient test outcomes and pathology reports will trickle in past the clini-
cal month's end date. If you want to be assessed primarily on the quality of your research work, you
should try to craft clinical responsibilities that require the least amount of follow-up, such as inpatient
rounding.

"Buying Out" of Clinical Time

If you secure additional funds for your department, it is possible for you to be released from some or all
of your clinical duties. However, if you request a reduction of 20 to 25 percent in your clinical duties, for
example, because you have secured an R01 grant from the National Institutes of Health, someone else in
the department will have to take on those obligations. Is there a new hire who can do that? Or a physi-
cian-scientist who is planning to close down or scale back his or her lab? If no one can take over your
clinical duties, then no matter what the division or department chair thinks of the idea or what promises
were made during the job negotiation process, you will not receive the additional protected time. You will
need to find out what the funding situation is at your medical school or academic health center to deter-
mine whether buying out is an option. You need to have these discussions prior to entering into the con-
tract and to get the commitments secured in writing.

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> *The issue of protected research time—not the compensation package and lab space—is the single most important negotiating point for junior faculty. If the institution is not willing to specify a time split in writing, you should worry.*
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> —Todd Golub, HHMI and Dana-Farber Cancer Institute
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Getting What You Need and Want

How to negotiate. Present your requests clearly. Make a list of what you really need and explain why to the person in charge of your recruitment. Indicate any equipment you would be willing to share. Your recruiter can use this information as your advocate in requests to the relevant deans who provide the actual recruitment dollars. Don't decide between departments based on offered dollar amounts and don't pad your requests. But do be sure that you will be able to do the research that you hope to do.

When the institution responds and you begin to discuss the terms of employment, be prepared to make trade-offs. Knowing what is essential to you is crucial at this time.

The offer letter. The fruits of your negotiations should be reflected in an official letter from the institution offering you a job. Work with the institution to craft as comprehensive a letter as possible. The letter is usually your contract, so take it seriously. In addition to the basics (e.g., title, salary, and research support), the letter should detail the timing, schedule, process, and requirements for tenure.

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> *I tell all of my postdocs who are negotiating for faculty positions: Once you sign on the dotted line, don't count on getting anything you haven't already been promised, no matter how reasonable it might seem.*
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> —Thomas Cech, HHMI
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Medical Center Career Tracks

In general, a faculty member in a basic science department in a medical center holds a tenure-track appointment, with responsibilities for research, teaching, and service. Such appointments are regarded as the most stable types of academic appointments because the institution assumes some obligation for salary and other types of support. However, in some departments, there may be faculty appointments that are not on the tenure track. For these individuals, the primary responsibility is research, with limited responsibilities in teaching and service. In this case, the faculty member may be entirely responsible for raising funds for his or her salary and for all other expenses needed for scientific research. Such appointments are generally given for a limited period, subject to renewal at the discretion of the department chair.

There are many different types of faculty appointments in clinical departments, such as medicine, pediatrics, or pathology. For example, in some schools, these are divided into three types of appointments: (traditional) tenure track, medical-clinical track, and clinician-educator track. The availability of different tracks provides faculty members the opportunity to choose how they want to be evaluated, for both tenure-track and nontenure positions. The tracks usually require different degrees of effort in the areas of clinical care and research, and accommodate individual and team effort differently. They also require and reward various degrees of scholarly work; for example, a full-time clinician is not expected to publish as much as a tenure-track researcher. In addition, whereas teaching and administration may be expected in every track, they may be recognized as more important in some than in others. You should research the track system at your school and ask questions during the interview specifically about the track you should be on.

Handling Multiple Offers

Multiple offers are gratifying, but they make life complicated. The important thing is to deal honorably. The following rules apply:

◆ Keep all parties informed of the status of your other applications.

◆ Use your leverage to ask an institution to match an offer but only if you intend to accept the offer.

◆ Be prompt to refuse, so that other candidates may be considered for a job you don't want. Keep in mind, however, that it can be risky to decline all your other offers before you've accepted your first choice in writing. There have been cases when firm verbal offers have been withdrawn because of a university-wide hiring freeze.

◆ Ask for an extension of a deadline if you need to, but don't miss a deadline.

After reading this chapter you should feel better prepared to tackle your job search and decide which offer to accept. To help you in the decision process, discuss all the pros and cons with those you trust. Once you have made a decision, sleep on it. When it is finalized, don't look back.

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Chapter 2

UNDERSTANDING UNIVERSITY STRUCTURE AND PLANNING FOR TENURE

You have no doubt spent many years in academic institutions and are familiar with their overall structure. But now, as a tenure-track faculty member, you are entering into a new set of relationships with your professional colleagues. Perhaps for the first time, you will have to deal with many of the university's administrative offices to fulfill professional responsibilities apart from those associated with your laboratory research.

As a young faculty member you will need to

◆ Get to know people who will support your scholarly efforts, including the faculty affairs dean, the department chair, department and college business personnel, research infrastructure personnel, and more established faculty members who can serve as mentors.

◆ Understand faculty governance, including the faculty senate and university committees.

◆ Know about research infrastructure, including research support services, indirect costs, institutional review boards, and conflicts of interest.

◆ Find out what are the expectations for beginning, independent investigators with regard to teaching, advising, service, and scholarship.

This chapter provides you with a starting point for obtaining this type of knowledge. It begins with an overview of the "typical" structure of a research university and an academic health center, as well as the resources available to a beginning investigator. It also discusses the professional responsibilities of academic faculty outside the laboratory, including teaching and service and, in the case of physician-scientists, patient care. Finally, it will give you some insights into how decisions about tenure are made at a university and how you can prepare for this milestone.

ORGANIZATION OF A "TYPICAL" UNIVERSITY

Although the major goal of U.S. universities is the advancement and dissemination of knowledge, universities also need funding to support their activities. A university must seek revenue from a variety of sources (see figure 2.1), and more and more, faculty members are encouraged to generate income. You will need to make your research program either self-supporting or demonstrably worth its cost in some other way.

Most U.S. research universities have roughly similar organizational and reporting structures. The titles of the executive officials may vary, but their functions are generally the same. The organization of a university's administrative staff and its methods of operation reflect a strong tradition of faculty dominance.

University-Wide Responsibility

◆ *Board of trustees or board of regents:* The university's highest authority, this governing board is composed of academic, business, and community leaders who hold appointed or elected positions with specific terms. The board meets regularly to review all major policy, financial, and management decisions, including decisions about faculty appointments, promotions, and tenure.

◆ *President or chancellor:* (Note: For this discussion, "president" is interchangeable with "chancellor." In some state university systems, the president oversees and coordinates the activities of the member universities, and a chancellor heads each university within that system.) The university's chief executive officer, this individual has general oversight of the university's academic programs and financial health. He or she is also the university's public spokesperson, dealing with "big-picture" issues such as relationships with the legislature and other funding bodies, alumni relations, and fund-raising.

◆ *Provost or vice president for academic affairs:* As the university's chief academic officer, the provost has programmatic and budgetary oversight over all academic activities. The provost reviews the appointment papers of new faculty members and receives reports from the promotion and tenure committee.

Figure 2.1. Annual revenue sources at a typical university

Grants and contracts (30%)

State appropriations (27%)

Sales and services (23%)

Tuition and fees (10%)

Other* (10%)

*Includes individual and corporate contributions, interest, and dividends.

Source: Tony G. Waldrop, University of North Carolina–Chapel Hill.
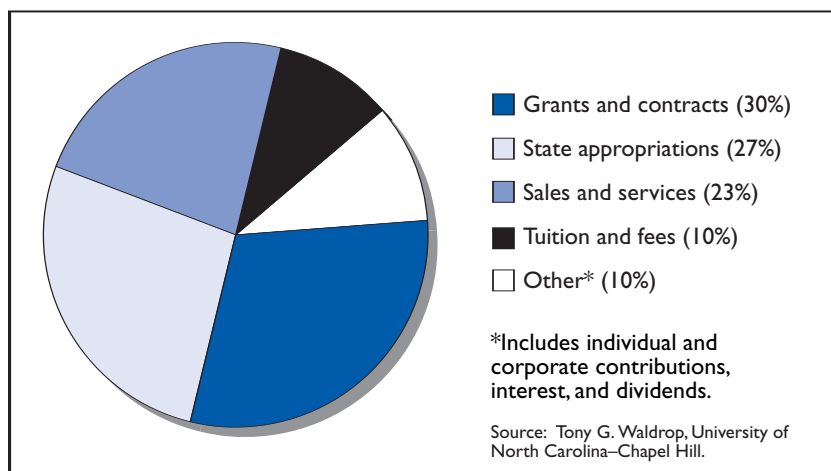
The deans of the various colleges report to the provost for academic-related matters. In some universities, vice presidents who are involved with academic affairs (e.g., research, student affairs) also report to the provost.

◆ *Vice president for administration and finance:* The university's chief financial officer, this individual is in charge of the fiscal affairs of the university and often also oversees diverse functions such as facilities planning and construction, human resources, and campus services (e.g., parking, public safety, maintenance, and mail service).

◆ *Vice president for research:* The university's chief research officer, this individual oversees grants and contracts, research funding, research centers and institutes, issues relating to technology transfer (patenting and licensing), and research-related committees such as Institutional Review Boards (IRBs) for human subjects research and institutional animal care and use committees. At some universities, the vice president for research also deals with scientific ethics issues.

Other vice presidents have responsibility for other areas that may affect the life of a faculty scientist directly or indirectly. These include the following:

Consult the Faculty Handbook

Your university's faculty handbook (often available online) is an invaluable resource for learning about the institution's organization and reporting structure, policies and procedures, and resources to support your research.

◆ *Vice president for information technology:* This individual oversees the university's computer facilities and telephone systems.

◆ *Vice president for health sciences:* This individual is responsible for the university's health-related institutions, including the medical center and the other health professions schools. (See "Organization of a 'Typical' Academic Health Center," page 28.)

◆ *Vice president for student affairs:* This individual oversees dormitories, recreational facilities, and other necessities of student life and is concerned with issues of student well-being.

◆ *Vice president for development:* This individual manages fund-raising, alumni networks, and university relations.

School- or College-Level Responsibility

◆ *Dean:* All department chairs report to the dean, who is responsible for the administration of a school or college. A university may have several schools or colleges. Each college may also have an associate or assistant dean or both. Not all deans are permanent appointments. For example, associate dean positions may be renewed annually and the individual typically runs an active research lab.

◆ *Department chair:* Each college is likely to have several departments, and in the sciences, separate scientific programs within each department. The dean typically appoints the department chair, with input from the tenured faculty, for a limited time period. Within that time frame, however, the department chair exercises considerable control over the allocation of resources within the department, including space, use of support staff, and purchases of equipment and supplies. The department chair makes teaching assignments and oversees the evaluation of faculty performance. The departmental promotion and tenure committee makes its recommendations to the department chair, who then presents the recommendation to the university-wide promotion and tenure committee.

As a principal investigator, you will primarily report to your department chair. If you have an appointment in more than one department, or in a department and in one of the university's separate research centers or institutes, you may have to report to more than one individual. Each department's interest in your efforts should be spelled out in your offer letter. Usually, the reporting relationship is a matter of "following the money"—where your salary comes from is where your reporting responsibilities lie. (See chapter 1, "Obtaining and Negotiating a Faculty Position.")

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> *When a junior faculty member directly or indirectly experiences discrimination or harassment, he or she needs to go to his or her chair and then to the dean. This is critical. Witnesses are not needed for the dean to have to address allegations.*
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> —Linda Walling, University of California–Riverside
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ORGANIZATION OF A "TYPICAL" ACADEMIC HEALTH CENTER

An academic health center within a university is a complex set of institutions, typically a medical school and hospitals; outpatient centers; and, in many cases, schools of nursing, pharmacy, and other allied health professions. Because much of the teaching conducted under the auspices of the medical school actually takes place in the hospitals and clinics, these organizations should have agreements or understandings in place that allow the faculty to appropriately carry out activities, from teaching to research to the provision of clinical care.

Key academic health center officials include the following:

◆ *Vice president for health sciences:* This individual oversees the entire complex and reports to the president of the university.

◆ *Chief executive officer(s) of the hospital(s) and clinics:* These individuals are responsible for the day-to-day operations of the hospitals and clinics and report to the vice president for health sciences.

Administrative Structure of the School of Medicine

The administrative structure of a medical school parallels that of the university in many respects. However, one distinctive feature is that the school is composed of clinical and basic science departments.

Medical school officials include the following:

◆ *Dean:* The dean's functions are similar to those of the dean of any other university college; the only exception is that he or she may also serve as vice president for health sciences. On administrative matters (e.g., procurement), the dean of the medical school may report to the vice president for health sciences. On academic and faculty matters, the dean reports to the provost. The medical school often also has associate and assistant deans with specific areas of responsibility.

◆ *Department chairs:* As elsewhere in the university, the chair is the administrative head of the department.

◆ *Division chiefs:* Frequently, large clinical departments in a medical school are grouped into divisions. In such cases, a scientist may be a division chief who, in turn, reports to a department chair.

If your appointment is in a basic science department, you report to the department chair; if your appointment is in a large clinical department, you usually report to the division chief. It is not uncommon for an investigator to hold a primary appointment in a clinical department and a secondary appointment in a basic science department or vice versa. In this case, the investigator reports to the department in which the primary appointment resides.

PEOPLE YOU SHOULD GET TO KNOW

As a beginning investigator, you will want to quickly learn which individuals can affect your career progress. They include

◆ Department chairs and division chiefs

◆ Full professors within your own department or division

◆ Senior physicians (if you are a physician-scientist)

It's also a good idea to get acquainted with faculty in your own department and in other departments whose research interests are complementary to your own. You may find, for example,

◆   Colleagues with whom a research collaboration is possible

◆   Colleagues who will have a good understanding of any health and safety risks associated with your research, and who can advise you about the policies of the university and safe procedures for controlling research risks

You should also be sure to get to know your departmental business manager and the other administrators in your department or division. These individuals are generally very experienced in dealing with matters such as requesting maintenance, purchasing, tracking grant expenditures, and a host of other issues that you will not have time to deal with in detail. These individuals will also be valuable in preserving stability when inevitable changes such as the retirement of a chair or division chief take place.

FACULTY GOVERNING BODIES AND COMMITTEES

Faculty Senate

A representative body of faculty members, sometimes called the faculty senate, serves as the principal channel of communication between faculty and university administration. The faculty senate may elect a smaller executive committee to implement its actions. It can make policy recommendations to the university president and appoint faculty to serve on university committees as well as faculty senate committees. The senate weighs in on the appointment of academic officials and on performance reviews of these officials. It meets regularly during the year.

University Committees

The faculty accomplishes its work through an array of standing and ad hoc committees. The names of committees and their mandates vary among universities, but representative types of standing committees include the following:

◆   *Promotion and tenure:* Reviews recommendations for faculty promotion and tenure as well as policies and procedures in these areas.

◆   *Admissions:* Establishes admissions requirements.

◆   *Academic requirements:* Establishes grading systems and graduation requirements.

◆   *Awards:* Makes recommendations regarding faculty who should receive special awards from the university. Nominations for such awards can be critical to the development of a junior or senior faculty member's career.

◆   *Curricula:* Approves new curricula and reviews existing ones.

◆   *Information technology:* Makes recommendations regarding faculty computing needs and concerns.

◆ *Faculty and staff benefits:* Makes recommendations on health and life insurance, leave, and retirement.

◆ *Ethics:* Establishes guidelines for appropriate conduct of research. Reviews cases of unethical conduct by faculty.

◆ *Human subjects research:* Establishes policies for the ethical treatment of human research subjects and ensures compliance with federal regulations.

◆ *Long-range planning:* Develops a long-range plan for the university.

◆ *Research:* Establishes policies to promote research and distributes university research funds.

◆ *Radiation, biological, and chemical safety:* Establishes procedures to carry out institutional policies for complying with regulations governing the use of hazardous materials in research.

◆ *Use and care of animals:* Establishes policies for the humane treatment of animals used in research and ensures compliance with federal regulations.

The meeting schedules and workloads of these committees vary considerably. Generally, committees that have responsibility for case-by-case review of individual applications or projects are the most labor-intensive. However, the workload of a policy committee may suddenly expand when it finds itself dealing with a "hot" issue. (Further discussion of a principal investigator's priorities with respect to committee work can be found in the section "Responsibilities Beyond the Laboratory," page 35.)

Departmental committees can include standing committees (such as those responsible for departmental courses and curricula, admission of graduate students, and selection of residents and fellows) as well as committees created in response to a particular need (such as the recruitment of a new faculty member).

SUPPORT FACILITIES AND SERVICES

Universities provide considerable support to aid faculty in their research, teaching, and public service. Support includes traditional campuswide resources such as libraries and media centers, scientific or technical services commonly referred to as "core facilities," and administrative offices established to help faculty complete grant applications and comply with regulatory requirements. As a scientist, you must know what centralized facilities exist to support you.

You are probably already familiar with the traditional campuswide resources and core facilities at your institution but may have never dealt with administrative support services. Listed below are several offices that may prove essential to you as you get your lab off the ground.

Regulatory Compliance Office

Regulatory compliance may be handled by the university-wide office of research or a similar office in your college or by several offices devoted to specific regulatory issues. Regulatory compliance officers keep track of the licenses and approvals you will need to comply with federal and state regulations for research. Visit them early to find out about the following:

◆ Requirements for radiation safety if you intend to use radioactive materials. You may need to attend a training session. You will need to obtain authorization of the Radiation Safety Committee to procure and possess radioactive materials.

◆ Requirements for the possession and use of bloodborne pathogens and other infectious materials and for recombinant DNA research. You may have to register your research with the Institutional Biological Safety Committee or have it approve your research.

◆ Licenses needed for the use of proprietary reagents and materials and approvals for stem cell research.

◆ Approvals for human subjects research. Your research protocols will need to be reviewed by an IRB. Because these boards typically meet monthly and the review process can be long, find out about the requirements early.

◆ Requirements for carrying out studies on animals. You will need to have any research protocols that involve animals reviewed and approved by the Institutional Animal Care and Use Committee.

◆ Requirements for using lasers and chemicals that have a high degree of acute toxicity and for disposing of hazardous chemical waste. Your institution will have specific protocols and practices to follow for using lasers and handling hazardous chemicals.

Environmental Health and Safety Office

Beginning investigators share a responsibility for laboratory safety. It is important that you participate in the health and safety program of your institution by being familiar with the health and safety guidelines that apply to your research. You should make sure the members of your research group know the hazards that may be present in your laboratory, are trained in safe work habits, and know how to deal with any emergency that may arise. Your institution's environmental health and safety office provides services that can help you with this responsibility. The office typically offers safety training programs, technical assistance, regulatory compliance assistance, risk assessments, and services to test the integrity of safety equipment.

Grants and Contracts Office

Staff of this office can tell you about available university financial support and help you apply for it, and they can provide information about outside funding opportunities. This office typically approves budgets prior to grant submission and, in some cases, controls the electronic submission of grants. In addition, this office can help you ensure that your grant application is in compliance with university policies and government regulatory requirements and that it has the necessary institutional

approvals and signatures. Remember to plan ahead; the grants and contracts office may require a few days to a couple of weeks to turn around your grant. Check with your institution's grants and contracts office to find out how soon they need to see your grant application.

Technology Transfer Office

The Bayh-Dole Act of 1980 gives universities the right to elect ownership of the inventions made in the course of federally funded research. Your university has responded to this incentive by establishing a technology transfer office to manage the patenting and licensing process. (See chapter 11, "Understanding Technology Transfer.") Visit the technology transfer office early in your career, keep the staff informed of your research, and let them help you determine whether any discoveries you make are worth licensing for commercial development. The office will also provide guidance on record keeping and documentation to protect your lab's intellectual property. (See chapter 8, "Data Management and Laboratory Notebooks.")

Procurement Office

This office manages purchasing for the university, and you may be required to use it to buy equipment and supplies. The office can negotiate group or bulk discounts. Its staff is familiar with the full range of vendors and products and can help you arrange custom purchases. Staff members are also knowledgeable about regulatory requirements related to the products they buy. They also keep track of payments and receipt of goods, thereby providing a valuable accounting function for your lab.

Human Resources Office

The human resources office can answer your questions about your own employee benefits and can help you in your role of supervisor. Before you hire your first technician or other support staff, visit this office to find out your university's rules and policies concerning employing and terminating staff, on-the-job discrimination, sexual harassment, and performance evaluation of staff. It is very important that you follow these rules and policies, because they involve matters of federal and state law. In addition, find out whether there is a union at your institution and whether any collective-bargaining agreements or union-related rules affect your interactions with university staff or students. (See chapter 4, "Staffing Your Laboratory.")

Public Relations Office

The public relations office keeps the world outside informed of the achievements of the university and its scholars. Its staff maintains contact with the news media and can help you prepare for an interview, translate your findings into "sound bites," and learn how to field questions comfortably.

Development Office

This office in an important administrative branch that faculty are becoming more involved in. It is responsible for coordinating and generating philanthropic support for development of the university by seeking money from individuals, including alumni, companies, trusts, and other organizations. Contacting your college or university's development office will allow special projects to be highlighted in fund-raising activities.

Sources of Information on Research Ethics and Human Subjects Research

Government Agency Web Sites

Office for Human Research Protections, Department of Health and Human Services (DHHS)
http://www.hhs.gov/ohrp
This office coordinates implementation of federal requirements for the protection of human research subjects and provides staff support to the secretary's Advisory Committee on Human Research Protections.

Office of Research Integrity, DHHS
http://www.ori.dhhs.gov
This office promotes integrity in biomedical and behavioral research supported by the U.S. Public Health Service. It monitors institutional investigations of research conduct and facilitates the responsible conduct of research through educational, preventive, and regulatory activities.

National Institutes of Health Stem Cell Research
http://www.ninds.nih.gov/stemcells
This site includes policies and requirements for research on human stem cells and guidance for investigators and IRBs.

U.S. Food and Drug Administration (FDA): Guidance for Institutional Review Boards and Clinical Investigators, 1998 Update
http://www.fda.gov/oc/ohrt/irbs
This site gives the FDA's current guidance on the protection of human subjects of research.

Private-Sector Web Sites

Association for the Accreditation of Human Research Protection Programs
http://www.aahrpp.org
This association sponsors an accreditation program for institutions that engage in human subjects research.

National Reference Center for Bioethics Literature
http://bioethics.georgetown.edu
The center provides a free reference service to the public, free bioethics database services, a Syllabus Exchange Clearinghouse for educators, annotated bibliographies, and other services to facilitate the study and teaching of bioethics. Staff at the center compile the *Bibliography of Bioethics*, an annual listing of 3,000 to 4,000 citations.

Public Responsibility in Medicine and Research
http://www.primr.org
This organization promotes the consistent application of ethical precepts in both medicine and research.

Responsible Conduct of Research
http://rcr.ucsd.edu
This site is sponsored by the University of California–San Diego and is funded by the National Institutes of Health Office of Research Integrity, the Department of Energy, and the DHHS Office for Human Research Protections. It includes educational materials for research ethics.

RESPONSIBILITIES BEYOND THE LABORATORY

Your roles as a faculty member form a triad of research, teaching, and service. As a scientist at a major university, you will focus principally on research. However, teaching and directing the research of students and postdocs will also be important and gratifying aspects of your activities. Your service responsibility to the university will occur mostly through service on committees. This, too, can be personally and professionally rewarding. If you are a physician, you may also serve the university through your patient-care activities.

Teaching

As a new faculty member, you may find juggling your teaching and research responsibilities to be a bit overwhelming at first. It's a good idea to remind yourself of the value of what you are doing—conveying knowledge and an appreciation of science to young people and possibly inspiring some of your students to pursue their own science careers. (See chapter 13, "Teaching and Course Design.")

To have time to get your laboratory operations under way, you may wish to negotiate a lighter teaching load during your first year as a faculty member. Other circumstances may also make it necessary to reduce your teaching load, for example, if your department has given you a heavy responsibility in another area or if you have family or personal problems. Talk to your department head about the options that may be available to you.

No matter when your teaching duties begin, take the time to prepare for them. Work up your lectures, take any "how to teach" courses that are offered on campus, and, if you can, sit in on your colleagues' lectures.

Also bear in mind that teaching gives you an opportunity to meet students who in the long run may be interested in research in your laboratory. At many schools,

> *At the same time I was building my research group, I was also teaching. It took about 10 years before I found real joy in teaching. But even in the very early years, I noticed that teaching was a tremendous stabilizing feature for my life—very unlike research, which can be discouraging. With research, there are times when you feel as though you've lost ground and you know less than you did the week before. Whereas teaching is much more steady—you put in a certain number of hours of work and something good comes of it. So, I think the combination of a teaching and a research career is a nice one in that teaching can fill out the dips that are the normal part of doing research.*
>
> —Thomas Cech, HHMI

younger faculty members often vie with senior faculty for the opportunity to teach courses to "undeclared" graduate students. Learning how to teach effectively means that you may have more opportunities to interact with undergraduate or graduate students in your department and in others. (For a discussion of balancing teaching and research responsibilities, see chapter 6, "Time Management.")

Committee Work

You will be expected to participate in one or more committees, and your contributions will be evaluated as a component of your service requirement for tenure. Although you should take this responsibility seriously, you also need to be judicious in your choice of assignments. Some committees—especially those that review individual research protocols or applications (e.g., IRBs for human subjects research or admissions committees)—are very labor-intensive. Others may deal with politically sensitive matters that may be difficult for a new professor. For example, you might not want to be on a curriculum committee if a controversial restructuring is under way and your department has a stake in the outcome. Such an assignment would be best left to a more senior colleague. Other committees may deal with matters irrelevant to your concerns as a scientist. So, before you accept a committee assignment, ask for a detailed description of what will be expected of you in terms of time commitment and the nature of the decisions to be made.

Many committees, however, do give you a decent return on your time investment. Serving on a faculty search committee may give you a voice in deciding who a new colleague will be. You might also want to be on a committee that puts together a

> *At the assistant professor level, you are expected to be setting up your research program and keeping your head down. Being on a high-profile committee can bring you quick visibility, but it can also make you powerful enemies.*
>
> —Milton Datta, Emory University School of Medicine
>
> *Engagement in the university is critical, but excessive administrative responsibilities can be harmful to research and teaching quality. Most pretenure faculty are involved in department-based committees or committees involving interdisciplinary graduate student training. College-, university-, and systemwide committees are more time-consuming and should not be emphasized until later stages of their careers. Learn to know when to say no!*
>
> —Linda Walling, University of California–Riverside

seminar program or scientific meeting. This will give you a chance to invite your former colleagues, leaders in your field, and new people with whom you may want to network. Work on an admissions committee for graduate students might be worthwhile because it will introduce you to graduate students who could work in your lab. However, work on committees responsible for the admission of medical students can be intensive and time-consuming, and the chances of significant future interactions with medical students (except M.D./Ph.D. students) are less.

A good strategy is to try to get on a committee where your expertise will be useful but where you will not be overburdened. Ask your department chair and mentors for advice on balancing committee work with your other obligations in the pre-tenure years.

Complying with Guidelines for Human Subjects Protection

If your research makes use of human subjects, you must meet the requirements of the IRB with respect to protection of patients' rights and well-being. Your research must be designed to be compatible with the IRB guidelines. In addition, you must obtain and document patient consent, comply with rules for protecting the privacy of patient information, and obtain the IRB's approval before you begin your research.

You may be required to maintain data on your research processes and outcomes for the IRB's inspection. All of this may slow your progress, but failure to comply can shut down your research program. Because obtaining IRB approval can take a long time, find out whether it is possible to apply before you begin your faculty appointment.

THE SCIENTIFIC INVESTIGATOR AND THE OUTSIDE WORLD

As a university-based scientist, you owe allegiance to several constituencies: to the university that supports you, to your profession, and to the general public that stands to benefit from your research. It is absolutely necessary, and possible, to keep these loyalties in harmony.

To keep your outside activities appropriate, you need to be aware of the university's rules and expectations with regard to

◆ Service in professional associations

◆ Conflict of interest and conflict of commitment, including limits on consulting activities

◆ Relationships with the news media and with government and political agencies

Consulting

As your career develops, you may find opportunities to consult with commercial entities such as biotechnology and pharmaceutical companies. Both you and your

home institution stand to benefit from relationships that extend your reputation, add to your knowledge and skills, and may result in practical applications of your discoveries. In addition, you may welcome the added income. Remember, however, that the university, as your employer, has primary claim on your labor and allegiance.

Many universities have developed explicit guidelines limiting the extent of a faculty member's work with other agents. It is critical that you know your institution's policies regarding your work outside the scope of university employment and your relationships with outside parties. Your institution should have a clear set of guidelines for these types of activities, and you may be required to report on them regularly. (Additional information on consulting can be found in chapter 11, "Understanding Technology Transfer.")

Public Service

An academic appointment carries with it a public service obligation. As your career progresses, you may be called on to participate on commissions or testify before government bodies on the meaning of your work or on its ethical or public policy implications.

Treat these invitations as a serious responsibility and, as you would with contacts with the press, stay close to the university public relations office. Remember, anything you say in public will reflect on your institution. It is easy to be misunderstood or quoted out of context.

You may also have opportunities to participate in public education—at science fairs, high school assemblies, or other community events. These opportunities can be both enjoyable and rewarding.

PLANNING FOR PROMOTION AND TENURE

You are more likely to succeed if you understand from the start how the decision regarding tenure and promotion is made at the institution you are joining. You can then start planning your strategy accordingly.

Criteria for Tenure

The official criteria for tenure form a "three-legged stool." You will be judged on your research, teaching, and service to the university, your profession, and the public. Whether or not these criteria have been spelled out in detail, the following expectations are typical.

Research. Your research must be of a quality and quantity that contribute substantially to your scientific discipline. Publication in peer-reviewed journals in your specialty and statements from individuals in your field who can testify to the quality of your research are the principal pieces of evidence showing that you meet this standard. Publications in scientific magazines that reach a wider audience give you additional credit. Substantial, ongoing research grant support is required; for

example, some institutions require that you have at least one NIH R01 grant. Additional evidence includes prizes and other recognitions of your work as well as invitations to present your work at conferences.

Teaching. You must have evidence that you are a competent teacher and that you fulfill your responsibilities to your students in a conscientious manner. Teaching is notoriously difficult to evaluate, but your department should have mechanisms to do so. Colleagues in your department may be assigned to supervise your teaching and offer guidance. Students' evaluations are another piece of evidence of your competence and rapport with your students. You may also be asked to report on your own teaching activities.

Service. You must demonstrate that you are willing to work for the betterment of the university, your profession, and the public at large. Service on departmental and other campus committees, on research ethics boards, on editorial boards of journals, and on grant study sections demonstrates your willingness to assume your share of responsibility. Invitations to serve on editorial boards and study sections also demonstrate scientific recognition outside of your institution. Work for professional associations and work as a consultant to government and industry also count as service.

The weight that will be given to each area by your tenure committee will depend on the mission of your institution and your department. In a premier research department or institution, research is primary, and it is the progress of your particular program that counts the most.

> *You build a research group by being in the lab as much as possible. The assistant professors who don't get tenure are the ones who spend all of their time in the office instead of in the lab.*
>
> —Thomas Cech, HHMI
>
> *The legs on the three-legged tenure stool have different thicknesses, with the research leg being considerably more substantial than the teaching and service legs. The second two have to be there or the stool topples, but it's impractical to think they carry the same weight as the research component.*
>
> —Matthew Redinbo, University of North
>   Carolina–Chapel Hill

The Review Process

The review processes for promotion from assistant to associate professor and tenure are intertwined. Tenure review entails a series of yes-or-no decisions by committees established at the department, school, college, and campus or university levels. The decision of the university-wide committee must be ratified by the president or provost of the university and governing board of the institution.

Universities vary as to whether the tenure process is open or closed—that is, whether you and anyone else will have access to the file containing the evidence for tenure and the record of the committees' deliberations. Regardless, a candidate usually has an opportunity to appeal a negative decision.

The process unfolds *roughly* as follows:

◆ During your second or third year of employment, your department chair creates your promotion and tenure dossier (see below for details about what it should contain).

◆ Before the end of your third year, the tenured faculty within your department vote on whether to recommend your reappointment for another three years.

◆ After the vote, your department chair meets with you to discuss any problems that may hinder your future prospects.

◆ During your fifth and sixth years, letters are solicited from both internal and external experts in your area and comments are solicited from your current and former trainees. At some institutions this may include solicitation of outside letters inquiring about your progress.

◆ The tenured faculty in your department review the materials and vote on whether you should receive tenure.

◆ If the department votes in your favor, your tenure dossier goes forward to the college's or university's appointments and promotions committee. Your department chair goes before this committee to discuss your qualifications.

◆ If this committee's decision is favorable, the package is sent to a university-level ad hoc or standing committee. The package is then sent to the provost and university president (or chancellor) and then on to the governing board for final approval.

Your Tenure Dossier

You should have the opportunity to contribute to your dossier. It should include the following:

◆ Your personal and professional history—essentially an extended CV detailing your education; academic positions and other professional employment; honors, prizes, and achievements; invited lectures and conference presenta-

tions; offices in professional societies; editorships of journals and other learned publications; grants received; and service on study sections

◆   A list of your publications and other creative works

◆   A summary of your teaching activities, including courses you have taught, other contributions to the university's instructional program, the results of students' evaluations, and your own report of your teaching activities

◆   Details about the work and subsequent placement of graduate students supervised

◆   A description of your internal and external service to the university, your profession, and the public

◆   A statement of your research goals and accomplishments, expressed so that members of a campuswide tenure and promotion committee can appreciate the importance of your work

◆   Letters from outside reviewers, who should be leading experts in your field and aware of your work (you may be asked to suggest several of these scientists)

> *Nothing is too trivial. If you were recognized in some way, make sure it appears in your dossier.*
>
> —Tony Waldrop, University of North Carolina–
> Chapel Hill
>
> *On the clinical side, it comes down to billable time—the clinical hours you work. The physician-scientist must find a department chair who's supportive of his research and communicates this to others in the department and institution.*
>
> —Milton Datta, Emory University School of
> Medicine

Time Frame for Progress Along the Tenure Track

The exact time frame for tenure and promotion has been established by your institution. In general, if you are appointed as an assistant professor, you can expect to be considered for advancement within about six years. Set specific, achievable objectives right at the outset of your career, with timelines that tell you what you need to accomplish each year. The whole process will seem more manageable, and you will be able to make realistic career decisions based on your progress.

Year 1. You should

◆ Set up your lab as soon as possible. Try to remodel your lab space, order equipment, and hire technicians before you arrive. If, after you arrive, you encounter problems, you may need to revise your tenure schedule.

◆ Learn your institution's ground rules for tenure.

◆ Ask for a faculty mentor if you are not automatically matched with one. You need someone who is effective in helping you wade through department politics and protocol. You may need an unofficial mentor if the official one disappoints you. In this case, be tactful.

◆ Get to work. If appropriate, write up your postdoctoral research and submit it to a journal.

◆ Accept committee responsibilities, but avoid becoming bogged down. Think carefully about the workload of any committee you are asked to join. You also need to consider the nature of the work. Some committees may be too politically sensitive to be of much use so early in your career. (See chapter 6, "Time Management.") In general, it is a good idea to ask your mentor before accepting to sit on any committee.

◆ Enter the "grantsmanship" game. You may want to start by applying for small grants ($5,000 to $25,000) from your own institution or from other sources to test the waters as you begin work on your major R01 grant submission.

Year 2. You should

◆ Try to publish the research you did in your first year.

◆ Apply to NIH or the National Science Foundation for a basic research grant. (See chapter 9, "Getting Funded.") Ask your mentor and other colleagues to review your proposal.

◆ Teach with the tenure review process in mind. Have your chair, mentor, and other colleagues observe your teaching. Be sure your students fill out the evaluation forms at the end of each course. You may want to create your own simple essay-type evaluation form for your students as well as the trainees and other personnel who work in your lab. You want their feedback. (See chapter 13, "Teaching and Course Design.")

Question: What do I need to do every year to help me attain tenure?

Answer: Update your CV, network with professional colleagues, and keep in close touch with your department chair and your mentors to evaluate your progress. Keep a "living document" of your accomplishments, activities, honors, and so on, so that you won't forget relatively small things, such as a poster presented by a student, or a short-lived but important committee that you served on. Having such a document will make assembling your tenure dossier much easier. In addition to these ongoing tasks, review your objectives and update them if necessary.

> *I advise clinician-scientists who do basic science to develop a "clinical niche." To the extent possible, they should focus on a clinical problem that has some relationship to their scientific work. For the purpose of tenure evaluation, this is advantageous because it helps others define you and to understand and describe what you do. For the purpose of time management, it takes you away from general medical care, which is extremely time-consuming. Having a stable of patients with a very narrow set of problems is a way of protecting research time. A generalist-type practice is death to a basic science research career.*
>
> —Ann Brown, Duke University School of Medicine

Year 3. This is the year the tenured faculty will vote on your reappointment. You should have been meeting regularly with your department chair to discuss your progress, so you should have a tenure file that will support your reappointment.

◆ Ask your mentors if you are on track for tenure. If not, take stock and consider adjusting your career goals at this point. If you are not doing well in a tenure-track position, and if you are a physician and want to stay in academia, this may be the time to think about moving into a research or clinical track.

◆ Ask your department chair for a checklist of the information to be included in the file.

◆ If your R01 was not funded, resubmit it and have a plan for backup funding. (See chapter 9, "Getting Funded.")

> *The general rule of "publish a good paper, then get a grant," is an appropriate goal for most beginning faculty. Use your start-up package to get those key results and then get them into the literature. It shows the funding agencies that your group is moving and being productive, which will enhance your chances to get those important first grants. Along the same lines, try not to submit premature grants; it is always better to wait a cycle or two if possible so that you can show stellar progress.*
>
> —Matthew Redinbo, University of North Carolina–Chapel Hill

Years 4, 5, and 6. You should begin to be recognized in your field for your research. The invitations that come your way to participate on panels or to serve on review committees are indications of success. If these opportunities are not occurring, take steps to gain exposure, perhaps by suggesting a session on your subspecialty at a national meeting. (See chapter 10, "Getting Published and Increasing Your Visibility.")

You need to address any issues that may hinder your bid for tenure. If you have not obtained funding, this should be your number one priority. Keep up your research, and continue your efforts to get the results into print.

Clearly, the road to a tenured faculty position is not an easy one. But if you think strategically—know what you want and need from your job, present yourself and your research to best advantage to obtain that job, and do what you should do each year to document your productivity—you will be well on your way to achieving your goal.

Designing and Equipping Your New Lab

You probably discussed your space and equipment needs during your interview and the negotiation process. Before you move into your new laboratory, create a detailed plan for how you intend to work within the space allotted to you. This will help you hit the ground running once you start your position. The following is a list of things you should do:

◆ Envision the relationships between the various workstations, preparation areas, and offices.

◆ Arrange for and help supervise any renovations.

◆ Order equipment and supervise its installation.

◆ Acquire any licenses required by regulatory agencies.

◆ You may need to attend training courses before you can order radioactive or hazardous materials or use animals in your lab; even the use of recombinant DNA needs to be approved.

◆ Put in place data management systems both for control of laboratory ordering and expenditures and for the documentation of your research.

A series of online articles, "The Art of Laboratory Feng Shui," at *Science*'s ScienceCareers.org (*http://sciencecareers.sciencemag.org*), will take you through these decisions. Another resource is a series of videos on laboratory safety, produced by HHMI and available at no charge from the Institute's online catalog (*http://www.hhmi.org/catalog*).

Special Issues for Physician-Scientists

Plotting Out a Career Trajectory

The career trajectory for tenure-track physician-scientists is different from that of Ph.D. scientists. The table below lists some of the goals you may try to achieve each year, none of which is "set in stone." The purpose of the table is to provide discussion material for your negotiation with the department chair. For example, you could present the table to the chair during the negotiation period and ask how his or her expectations differ from those listed in the table and why.

	Years 1 and 2	Years 3 and 4	Years 5 and Beyond
Clinical Duties	One month inpatient consult One-month outpatient clinic Protected time for research (70–80%) Guaranteed salary and start-up funds that include support for one trainee, one technician, and a half-time secretary Secure additional funds through internal university grants	One month inpatient consult Two outpatient clinics per month Protected time for research and salary support (50–70%) Ability to keep any unused start-up funds and retain one trainee, independent of current funding Apply for outside funding from nonprofit organizations and the U.S. government	Four to six weeks inpatient consult One to two "specialty" out-patient clinics per month Secure NIH funding (R01, K08, etc.) Two to three publications per year in good quality journals (top 25% of your field)
Teaching	Ten contract hours per year at medical and graduate schools in a variety of courses and teaching settings	Offer to organize a graduate school course (in addition to continuing the teaching efforts outlined in years 1 and 2)	Direct a medical school course (40 contract hours) Teach in a variety of other courses (5–15 contract hours) Attending duties (1 month per year)
Community Service	Network with individuals outside of your home institution	Review manuscripts Departmental and university committees Network with individuals outside your home institution	Review manuscripts Departmental and university committees Thesis committees Medical/scientific advisory boards for nonprofits NIH study sections Write book or review chapters

Special Issues for Physician-Scientists

Straddling the Worlds of Research and Patient Care

As a physician-scientist, you can be active in defining your role by pointing out the value you bring to the department beyond billable hours, such as a scientific perspective on patient care and important training and mentorship opportunities for students and residents. In fact, the federal funding agencies consider physician-scientists to be crucial to the translational science involved in moving from the map of the human genome to strategies for diagnosis and treatment of disease.

You can increase your visibility and security by doing the following:

◆ Creating allies who will stand up and protect you. Cultivate a few people in your field who think you're terrific.

◆ Making yourself essential by providing an important clinical skill or filling a crucial clinical need. Other clinicians who know your worth can become your advocates and help protect your interests. Advocates need not be in your own department, but they should rely on you and your expertise.

◆ Getting the word out that you're doing something. Actively communicate progress on your research with people who matter in your department or division.

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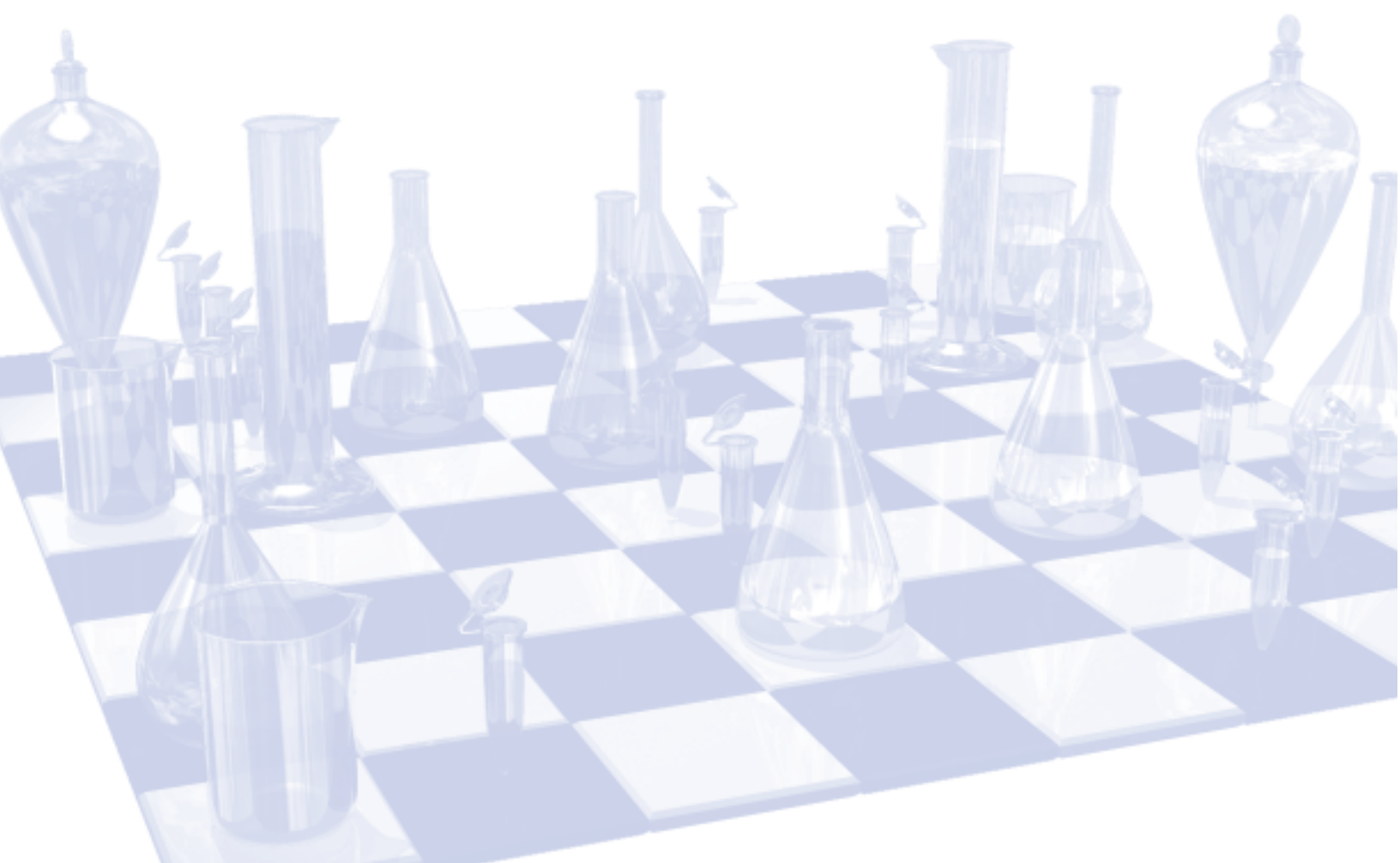
Chapter 3

LABORATORY LEADERSHIP IN SCIENCE

The day has finally come when you walk through the door of your own laboratory. You are the boss! What got you here is your creativity and scientific expertise. But you quickly realize that the day-to-day operation of the laboratory also requires strong leadership and management skills.

This chapter describes the skills and competencies involved in leading and managing a group of people. It also offers some suggestions on how to achieve them. It is organized in four main sections. The first provides a definition of leadership in the context of directing a scientific laboratory. The second describes the process for developing a vision for your laboratory; your main role as a leader will be to organize and motivate the people in your lab to enact this vision. The third is about different leadership approaches and how you might proceed in developing your individual style. The fourth discusses the role of the laboratory leader in building and sustaining an effective team—that is, how to communicate with the people in your lab, how to motivate them, how to make decisions and resolve conflicts, and how to set and enforce expectations and rules of behavior. This chapter is largely based on material developed by Edward O'Neil, director of the Center for the Health Professions at the University of California–San Francisco, as well as interviews with scientists with years of experience running laboratory research programs.

> *If I had one piece of advice to give it's that although you've been hired for your scientific skills and research potential, your eventual success will depend heavily on your ability to guide, lead, and empower others to do their best work.*
>
> —Thomas Cech, HHMI

YOUR ROLE AS A LABORATORY LEADER

What Is Leadership?

Before getting into the details of your responsibilities as the head of a lab, or principal investigator (PI), you need to understand what leadership is. Leadership is getting a group of people to enact a vision of what needs to be accomplished. Thus, according to O'Neil, leadership starts with a vision, and requires relationships with others to accomplish tasks.

Leadership = Vision + Relationships + Tasks

Put into practice, this means that the leader has to perform a number of functions, from coming up with a scientific strategy, to motivating people, to managing budgets.

Vision. A leader has to create a vision and set the direction for the lab. (See "Creating Your Vision as a Leader," page 53.)

Relationships. A leader enables others in the lab to do the work in a unified manner. Thus, a leader has to

◆   Build and manage teams.

◆   Create an environment where people are able to give and receive feedback.

◆   Motivate and support graduate students, postdocs, and technicians.

◆   Delegate responsibility to others when possible.

◆   Make fair decisions and manage conflicts.

◆   Communicate and listen.

◆   Be sensitive to diverse populations and needs (see chapter 5, "Mentoring and Being Mentored").

◆   Be a mentor to others, as well as seeking his or her own mentors (see chapter 5, "Mentoring and Being Mentored").

Tasks. A leader also has to manage the activities of lab members. This requires that the PI understands the core activity that he or she is responsible for directing. Beyond a basic knowledge of the scientific tools and processes used in the lab, the PI must also be able to

◆   Design projects and determine time frames (see chapter 7, "Project Management").

◆   Create budgets (see chapter 9, "Getting Funded").

◆   Write grants and papers (see chapter 9, "Getting Funded").

◆ Teach courses (see chapter 13, "Teaching and Course Design").

◆ Juggle many different demands at once (see chapter 6, "Time Management").

Leaders and Managers: What Is the Difference?

Although leadership and management are often used interchangeably, they do not mean the same thing. A leader influences the opinions and attitudes of others to accomplish a shared goal. A manager, on the other hand, is primarily an administrator, who makes sure that people and processes are in place to achieve the desired goal. Managers need to be able to plan, budget, organize, and solve problems, to keep a complicated system of people and technology running smoothly. As head of a scientific laboratory, you will need to be a leader and a manager.

Developing Leadership Skills

Some of the leadership skills mentioned above, such as developing a vision statement, may come easily to you, whereas others, such as motivating people in your lab or delegating responsibility, may prove more difficult. "Leadership development" is the process of improving your leadership skills. It involves establishing one or several goals for becoming a better leader and making a plan for achieving them. Here are some tips on how to go about it.

Choose a behavior that you want to modify. Say that a conflict arises between two postdocs in the lab; their projects have converged and now they are competing against each other over who should take charge. You realize that you should be keeping closer tabs on the experiments being done by everyone in your lab, as well as on the interactions among people.

Choose a specific goal for changing your behavior. You should choose a goal that is as specific as possible and state it in clear, measurable terms. For example, a goal that states "I will be better at communicating with people in the lab" is neither clear nor easy to assess. You will be more likely to achieve a goal that states "I will meet weekly with the postdoc who is working on project x to discuss in a direct and open way progress on the project and any issues that might be affecting the work." This way you will be able to tell if you have or have not followed through.

Determine a timeline for completion. You need to have a realistic deadline for assessing your progress. For example, "In one month, I will know what everyone in the lab is working on and will have set up scheduled meetings with each person."

Assess your progress. From the beginning you should have clearly stated the expected outcomes of your goal, so that you will know if you have achieved them. The questions you want to be able to answer are

◆ How do I know I have been successful?

◆ Who are the other people who will notice and be affected?

◆ What difference will they notice?

To know if your plan is effective, you will need to create open channels of feed-back. This involves asking people in your lab and your colleagues for feedback on how you measure up against your desired model (see "Giving and Receiving Feedback," page 60).

How to Improve Your Leadership Skills

Improving leadership skills is often a process of trial and error, but there are some more formal ways of going about it.

Find a mentor. To help you define and achieve a specific goal, identify someone who does what you would like to do. For example, if one of your limitations is making people feel valued for their work and accomplishments, you may want to observe how another PI recognizes and rewards the people in his or her lab and then attempt to model that behavior in your own lab. You will need to practice and probably modify your behavior to suit your own personality and situation. Similarly, you probably know colleagues who are good public speakers, cool under pressure, effective at managing time, or skilled at running lab meetings. Observe these people and identify specific positive behaviors that you see them use and then try to adopt these behaviors. You may also ask these colleagues for feedback and advice on your own behavior and progress. (See chapter 5, "Mentoring and Being Mentored," page 97.)

Read books and attend courses. You can aid your leadership development by reading books and taking courses offered at your university, especially if it has a school of management. Some of the scientific societies also offer seminars or short courses in laboratory management in conjunction with their annual meetings. You can also take advantage of the resources available through your institution's human resources department. A number of organizations, such as the Center for the Health Professions at the University of California–San Francisco (*http://www.futurehealth.ucsf.edu*) or the Leadership Learning Laboratory at the University of California–Davis (*http://sdps.ucdavis.edu/browse/hr/hrs021.htm*), can also bring tests and other resources to your institution.

Get to know your strengths and weaknesses. In most cases, you cannot change your personal qualities, but becoming aware of them can help you lead more effec-tively. You will be able, for example, to make the most of your assets and work around or improve on your liabilities. In addition, self-knowledge will make you more aware of the personalities of people in your lab and help you direct and sup-port them more effectively. You can take different tests to help you understand var-ious aspects of your own personality and how you behave in certain situations; one of the best known is the Myers-Briggs Type Indicator (MBTI). Appendix 1 (page 73) offers a brief description of the MBTI personality types and how these may play out in a laboratory environment. More information on the MBTI can be found at *http://www.myersbriggs.org*.

A popular way to understand your on-the-job strengths and weaknesses is to com-plete a so-called 360-degree feedback questionnaire. One example, Skillscope, pub-lished by the Center for Creative Leadership, consists of a series of questions that

you and others answer. Your supervisor, peers, and people you supervise rate you on what parts of your job (from communicating information and supporting the professional development of your staff, to administrative and organizational abilities and time management skills) you excel in and what parts could use improvement. The questionnaire also gives everyone a chance to say if they think that particular skill is important to your job. It is very enlightening (and an opportunity for discussion) to know what others consider your strengths and weaknesses compared with your ideas about them. Responses are anonymous, except for the supervisor's responses. More information on Skillscope can be found at *http://www.ccl.org*.

CREATING YOUR VISION AS A LEADER

Most people understand that the president of a university or the head of a large teaching hospital must have a vision for what he or she wants to accomplish, but how about someone running a lab? Even a six-person lab in which there is no clear vision is likely to have postdocs and graduate students heading off in their own directions, wasting time, and generating ill will. Developing a vision for everyone in the lab to share does not limit innovation. Instead, it provides a foundation for creativity from which new directions may be taken.

> *My vision is that we are going to regenerate the heart after a heart attack. This is really what I would like to accomplish with my career. Initially, I was worried that I would sound "sappy" in some fashion when I told people that I had a vision. I found that at first people may think it's a little odd, but pretty soon when they hear it again and again, you start seeing people nodding their heads and agreeing with you. Having a clearly stated vision does help to inspire in people the mission behind what you are working on.*
>
> —Charles Murry, University of Washington School of Medicine

How to Create a Mission Statement

The cornerstone for implementing a vision for your lab is the mission statement. It describes the kind of research you want to do, the motivation for your research, and the kind of atmosphere in which you want to work. It should take into consideration the history and current challenges of your lab and what you want to accomplish in the short and long term, with an eye to the future work of your department and institution as a whole. As you develop your mission statement, you might present it verbally to colleagues and your department head in an informal setting. Following input and adjustment, the statement should be written in about one paragraph.

As you develop your mission statement, keep in mind the following points:

◆ Decide what values you want for your lab (e.g., scientific excellence, discipline, teamwork, competition).

◆ Consider your social and financial goals, in addition to scientific ones.

◆ Craft a statement that you feel comfortable communicating to your peers, superiors, and lab members.

The following are two sample mission statements:

◆ *The goal of our laboratory is to be among the most successful and respected in the area of cancer genetics. The ultimate goal is to help develop better therapies and cures for cancer. To this end, we will collaborate with other researchers in the area and share our results and reagents. We will be recognized for being fair and collegial.*

◆ *Our lab aims to understand the mechanisms by which cells transport proteins. In particular, we will focus on technical challenges that others have not been able to overcome. A main focus of the lab is to train the next generation of scientists. We will create an environment that is conducive to learning and testing new skills.*

Keep in mind that mission statements are not operating plans or strategic maps for the lab, but they serve to shape these essential elements. In addition, they are not static; they evolve and change with time.

Once you have a mission statement that you are comfortable with, start saying it over and over to the people in your lab. Mention it at lab meetings, when people first join the lab, when you sit down to write a paper. Every decision you make from now on—from hiring staff to choosing scientific projects for the people in the lab to establishing how communication flows—should be made with this statement in mind.

Developing Your Mission Statement

◆ Paint with broad strokes, but also identify key measures of success.

◆ Provide both reasoned and emotional justification for the vision.

◆ Tie it to the values and culture of your department and school.

◆ Be clear and honest.

◆ Create a distinct future that distinguishes your research program from others, especially those of competitors.

DEVELOPING YOUR LEADERSHIP STYLE

Your mission statement is what sets the course for your lab, but how do you go about directing and motivating people to accomplish this vision? The way in which you carry out your role as a leader is called your "leadership style." It will depend largely on your own personality and the types of mentors you have had up to now. For example, you may find you feel more comfortable making decisions on your own, without seeking the input of others in the lab or colleagues. Or you may find it difficult to give unsolicited feedback to your students and postdocs. After a few months of leading your own lab, you will most likely develop a style that you feel comfortable with. But management experts tell us that different styles are required for different situations and different individuals, and that you should practice using a variety of such styles.

Four Styles of Leadership

Ken Blanchard, best known for the "One Minute Manager" series, and Paul Hershey proposed one classic research model for so-called situational leadership. They visualized leadership styles in terms of a continuing spectrum of directive and supportive behavior. Directive behavior involves clearly telling people what to do, how to do it, and when to do it, and then closely monitoring the behavior. Supportive behavior involves listening to people, providing assistance and encouragement, and then facilitating their involvement in problem solving and decision making. According to this model (see figure 3.1), the degree to which you direct and support people who work for you is influenced by their level of competence and their commitment to completing a given task.

Figure 3.1. Blanchard and Hershey model of leadership styles
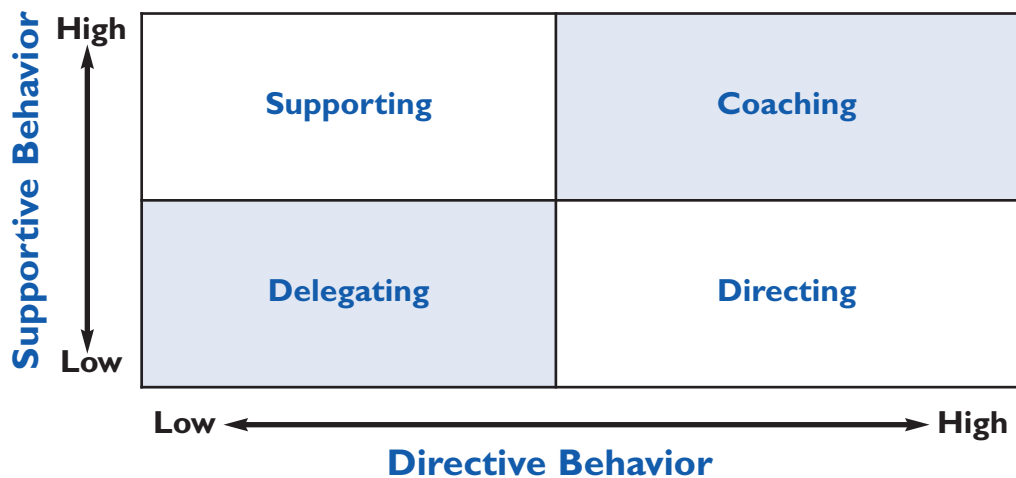
Source: Adapted from a concept developed by the Center for Leadership Studies, Inc.

The four styles of situational leadership are described below.

Directing. This style puts a high focus on task and a lower one on relationship. When the person you are supervising is not yet qualified or not sufficiently motivated to carry out a task independently, then you need to tell him or her precisely what to do at each step. For example, you may take this approach with a technician who has just started working in the lab and needs to learn an important technique that he or she will be doing routinely.

Coaching. This style puts a high focus on both task and relationship. As a PI, you would continue to direct the action of the person you are supervising, but also take the time to explain decisions, solicit suggestions, and support the individual's professional development. This leadership style is the most demanding. It requires a lot of time and emotional investment on the part of the leader. For example, soon after a graduate student joins the lab, you will probably have to show him or her different techniques and help him or her decide which experiments to do, but you would explain why and how they fit in with the lab's mission.

Supporting. This style puts a low focus on task and a higher one on relationship. As a PI, you would facilitate people's efforts toward accomplishing a given task and share responsibility for decision making with them. In a lab, the PI is likely to adopt this leadership style with most postdocs and experienced graduate students. For example, you would give the postdoc responsibility to choose what experiments to do but continue to discuss what these are and facilitate progress by, for example, helping the postdoc find someone to collaborate with so that he or she can get the next step of a project accomplished.

Delegating. This style puts a low focus on both task and relationship. As a PI, you would turn over responsibility for decision making and problem solving to an individual who has become more independent. For example, you would allow a postdoc who is ready to leave the lab to make decisions about what projects to pursue and collaborators to seek out without having to ask for your input first.

Delegating Tasks and Authority

Many PIs, especially starting PIs, are reluctant to delegate for fear of losing control or power. Delegating is important because it will relieve you of some of the day-to-day responsibilities. Assigning responsibility does not lessen your role in the lab. It merely gives you a capacity to handle greater responsibility. In addition, delegating serves to empower and motivate the people who work for you.

In deciding whether there is something you could delegate, ask yourself the following questions: What am I doing now that I'd like to see someone else do? Is there a person in the lab who is capable of handling and willing to take on a new responsibility? What could I do if I had more free time?

Once you have decided to delegate the responsibility for a given task, you need to

◆   Be sure you delegate the necessary authority with the responsibility.

◆   Give clear directions and make sure they are understood; keep two-way communication channels open.

◆　　Clearly define the responsibilities assigned to each lab member, and make this information known to everyone in the lab.

◆　　Once you have delegated, follow up to make sure the job is being done without interfering with it.

◆　　When you delegate authority to someone, be sure to back up that person when his or her authority is called into question.

◆　　Distribute responsibilities fairly among members of the lab.

> *Through the years I've learned that, on the one hand, there are a bunch of ways to treat people that generally work well; on the other hand, each individual case seems to bring up something new that you don't have experience with. So even though you think you've developed all of this experience, with the very next circumstance, you may have to fine-tune your approach, because every person is different.*
>
> —Thomas Cech, HHMI

BUILDING AND SUSTAINING AN EFFECTIVE TEAM

Today, more than any other time in history, science is a team sport—and the teams keep getting bigger. For many kinds of experiments, you need to integrate different kinds of technical expertise and backgrounds. Regardless of the size of your lab, there are some general guidelines for keeping the team members motivated and working effectively, from communicating and giving feedback to setting specific rules of behavior. They are discussed in the sections below. (For more information about how to collaborate with other labs, see chapter 12, "Setting Up Collaborations." For more information about how to select lab members, see chapter 4, "Staffing Your Laboratory.")

Communicating Within the Lab

You should communicate with laboratory members on a daily basis. If you are still doing experiments at the bench, you will be accessible to your lab members. But, if you spend most of your time in your office writing papers and grants, make an effort to walk around the lab at least once a day, if possible, and informally chat with people. Unless you need to concentrate on a task without interruptions, keep the door to your office open.

In addition to these informal interactions, formal meetings are an organized way to ensure that everyone is kept informed of the group's activities and results and for

you to reiterate your expectations and values. By all means, hold regular goal-setting and evaluation sessions: an annual lab retreat, periodic lab meetings involving the full staff, weekly or more frequent small-group meetings to discuss specific issues, and regularly scheduled one-on-one advisory meetings and performance evaluations. Group activities, held periodically, are also important for building morale and encouraging lab members to think of themselves as part of a team.

Research group meetings. Many research groups hold weekly meetings. One or more people in the lab take turns presenting what they've done since they gave their last presentations. They give an introduction, share their results and their interpretation, and then discuss what they plan to do next. Comments and suggestions from the research team usually follow. In some labs, especially larger ones, a research group meeting is a semiformal presentation with overheads or PowerPoint slides and can be a somewhat intimidating experience, especially for a graduate student. In smaller labs, these meetings may be more informal—for example, each person discusses what he or she did that week. These meetings are much more interactive. Yet, even in smaller labs, it's important to schedule occasional formal presentations so that students and postdocs can perfect their ability to speak about their research. Another good idea is to have joint research meetings with other labs. It is good experience for your lab members to give presentations to scientists outside your lab. It can help to clarify presentations and garner new ideas from those who aren't so closely involved with the project. It also extends your network and that of your students, which is especially useful when they are looking for jobs or letters of reference.

One-on-one meetings. Regardless of the frequency of research group meetings, you should meet often with each lab member to keep current with progress and problems. Invite your students, postdocs, and technicians to come into your office with their lab notebooks and show you what they've been working on. Many PIs meet with lab members for an hour each week. They may meet with them more frequently immediately after lab members have finished a series of experiments or when they notice that a lab member is struggling.

Performance reviews. The performance review meeting with lab members is an opportunity for you to clarify your expectations, review their recent accomplishments, and set performance goals. It is also a good time to talk about their career goals and how their work in your lab contributes to achieving those goals. Another important purpose of performance evaluations is to provide lab members an opportunity to give you feedback on your leadership style. Work

Guidelines for Effective Meetings

For most formal types of meetings you should have a predetermined plan for the meeting that states its goals and purpose:

◆ Solicit agenda items and distribute an agenda before the meeting.

◆ Have clear assigned roles for the meeting—that is, who will speak, who will take notes, who will lead the discussion.

◆ For each action item on the agenda, go over discussion points, make a decision, and determine postmeeting actions.

◆ Discuss what should be on the next meeting agenda.

◆ Follow up the meeting with a meeting summary and a to-do list.

with your institution's human resources department to make sure you conform to your institution's performance management process. Appendix 2 shows a sample performance review form, created by Tamara Doering. She gives the form to lab members a few days before the meeting. The form consists of two parts: a self-assessment section that is completed by the lab member before the meeting and a joint feedback section that is completed during the meeting. In addition to a focused discussion of short- and long-term goals, the twice-yearly meeting gives lab members an opportunity to give feedback on Doering's leadership style. The form offers some suggestions about what to evaluate and how to engage lab members in self-evaluation. Appendix 3 includes a checklist developed by HHMI's Department of Human Resources; it can also help you prepare for a performance feedback session with a lab member.

Small-group meetings. Some labs also have meetings attended by individuals working on specific projects or with specific techniques. This is where lab members deal with logistics and technical matters, and they hammer out experiments, trying to get different approaches to work.

Strategy sessions. Should you decide that your research needs to take a new direction, you may want to call an official strategy session. A strategy session helps the group identify the next most important questions and what experiments will answer these questions. Such a meeting also helps the group develop a shared understanding of the lab's direction and clarifies what needs to be done and who is interested in what aspects of the new research area. In addition, these meetings help you determine how potential conflicts and competing interests can be avoided.

> *If a PI has 20 people in the lab and you ask the PI at any moment, "What is person number 17 doing?" he or she should be able to give you a two-hour talk on this without any preparation. The sine qua non for being a good lab director is having all of this in your head.*
>
> —Thomas Cech, HHMI
>
> *In my lab, there are five or six breakout groups that meet once a week or two, and that works really well. It gives them a team-building experience.*
>
> —B. Brett Finlay, University of British Columbia

Journal club meetings. These meetings are an integral part of training new scientists and can vary in frequency from weekly to monthly, or as desired. The discussion of a scientific report serves to illustrate how to and how not to construct and test a hypothesis, what constitutes effective analysis, and how to report scientific findings. In addition, a journal club meeting reinforces the idea that reading current papers is essential to keeping up with the field. These meetings also provide an opportunity to communicate your values about science when discussing other people's work.

> *[At journal club meetings] we discuss papers and talk about their weaknesses, and it makes it clear that we don't want our papers to have those kinds of weaknesses. I think the scientific rigor issues come up as we go along.*
>
> —Tamara Doering, Washington University School of Medicine

Informal group activities. Organizing social occasions to celebrate a major accomplishment—publication of a paper, a job, a grant—is important for promoting your shared vision of the lab and building morale. In addition, most PIs agree that it is important that lab members occasionally socialize in a relaxed, nonwork environment. Such get-togethers can help promote team building and enhance communication among lab members. As you are establishing your lab, you might have to arrange these outings. After a while, they will occur more spontaneously. Don't feel that you always have to participate, and don't feel offended if you are not invited to all after-hours occasions.

Giving and Receiving Feedback

Giving and receiving feedback is a critical leadership skill. Receiving feedback from individuals in your lab will help you improve as a leader and help you steer people toward your vision. In turn, giving them feedback will help them develop as scientists and ensure that your expectations are met. Feedback should be given informally, on a daily basis, as well as during formal meetings. Giving feedback and communicating with your group on a regular basis help instill the culture of "feedback," and can also make it easier to approach lab members about specific situations or problems, since they are used to regular sessions with you. It also helps avoid unpleasant surprises from members of your lab.

Giving Feedback. When you give feedback to people in the lab, try to

◆ Time it well. Feedback during stressful times (e.g., when a grant deadline is looming) is rarely helpful, especially when either party is angry, or when someone is not ready to receive feedback.

◆ Be specific and objective. Focus your comments on first-hand data, actions, and behavior and not on the person or speculation about his or her intentions. For example, instead of saying "You are not focused enough on your work" or "You don't seem to care about your experiments," think of a specific instance that you thought was a problem. "We decided at our meeting that you would do these three experiments, but you only did one."

◆ Reinforce expectations. Provide feedback in terms of previously outlined goals and decisions (e.g., "We decided at the last meeting...").

◆ Avoid subjective statements. An example of such a statement is "I don't like the fact that you show up in the lab whenever you feel like it." Try instead to stick to objective arguments: "If you arrive at unpredictable times, it is difficult for other people in the lab to know when they can talk to you. Many people depend on your expertise and need to know when you are available."

◆ Present it in a constructive way. Feedback should be seen as a method of improving rather than as a punitive step. To this end, ensure that the student or postdoc has a plan for dealing with any problems you have identified and arrange a way to monitor progress. Why does the postdoc come to the lab late in the day and have an erratic work schedule? Does she need to adjust her daily routine and go to sleep earlier? Does she have a problem with getting transportation to and from the lab? Suggest ways to overcome these problems and agree on a deadline for reevaluating the problem: "From now on I expect you to be in the lab at 10 a.m. and to attend all scheduled lab meetings. Talk to Dave or Jane about carpooling to the lab. We can talk again in a week to see how you are doing."

◆ Make sure it registers. Feedback is often subject to distortion or misinterpretation. You may want to ask the student or postdoc to rephrase what you have said and talk about his or her assessment of the issues you raised.

◆ Avoid giving too much. Select the highest-priority issues to start with, and remember that time and space are needed for integrating feedback.

> "
>
> *Although I know it's important, it is hard for me to let people know when their behavior does not meet my expectations. When I first opened the lab, I was more uncomfortable with this than I am now. Basically, I'm quicker to call people on it now. If things are not working and the quality of their work is somehow slipping, or the effort that they are putting in is somewhat dropping, I have an easier time saying, "This isn't right, you have to change it now."*
>
> —Charles Murry, University of Washington School of Medicine
>
> "

Receiving feedback. Invite people in your lab to provide feedback on specific issues by asking questions during lab meetings or scheduled one-on-one meetings. Make it a point to meet with your department chair on a regular basis and have lunch with senior colleagues to get a sense of how they think your work is progressing and whether you are on track for getting tenure. (If they have not been paying attention to your work, this conversation will motivate them to start doing so). But remember, to get honest comments and suggestions, you must be receptive. If you respond angrily or defensively, those in your lab and other colleagues will be reluctant to give you their opinion. As you are listening to a comment, try to understand what the other person is saying. If something is not clear, ask for clarification. If the feedback is negative, take time to think about what you heard, even if you don't agree. What behaviors might have caused these perceptions? What changes, if any, do you need to make?

Making Decisions

As a PI you will be making tens if not hundreds of decisions a day, from determining which e-mails to open and what type of answer to give each one, to choosing to hire a new postdoc. In each case, the first step in making a decision involves understanding the demands of the situation by answering the following questions:

◆   How important is the decision I have to make? For example, hiring a new technician is a serious commitment. You will have to interview the candidate and carefully research his or her background before you make a decision. On the other hand, whether or not you agree to referee a paper is unlikely to carry very serious consequences.

◆   When do I need to make the decision?

◆   Do I have enough information to make the decision?

◆   How critical are the consequences of this decision?

◆   Who needs to know or cares about the decision I am about to make?

◆   Will I need assistance or approval from others?

◆   If I have made that kind of decision before, can I use the same approach?

Answers to these questions will help you choose the most appropriate decision style—that is, the degree to which you go at it alone or include others.

Making a decision in complete isolation. This decision style works best when you are under severe time constraints, there is no need for buy-in from other people, you alone have the best insight, or you are dealing with highly confidential information. For example, if another scientist approaches you to collaborate on some experiments for a paper that he is in a rush to publish, you may quickly decide whether it is worthwhile for you to get involved. You can make this decision without consulting anyone else if the work can be done by yourself or a technician. Another example would be to decide whether to referee a paper or write a reference letter for a postdoc.

Making a decision after consulting with other individuals, but without necessarily telling them why. You would use this decision style when you need input from others and have sufficient time to gather information. In general, this approach improves the quality of the decision, but you run the risk of involving people who are not really participating in the decision-making process, which may lead to resentment or misunderstanding. For example, if approached by another researcher to collaborate on a project, you may ask your colleagues whether they know this person and what his or her reputation is. A PI considering taking on a new research direction may consult with the department head and postdocs and students in the lab. But the decision ultimately rests on the shoulders of the PI.

Making a decision with the group. This decision style is helpful when you have few time constraints, need the buy-in or technical experience of the group, or need a creative response. It is more time-consuming than the two discussed above, but in some cases it improves the quality of the decision. For example, when deciding whether or not to invite a new postdoc to join the lab many PIs will decide jointly with existing lab members. Another example is when a PI has to decide whether or not to buy a new piece of equipment that he or she has little experience with. There may be postdocs in the lab who are more knowledgeable and can make a better decision.

Passing the decision on to others. It may be appropriate to let other people in your lab make a decision in cases where the decision is more important to them, you have little competence in the particular issue, or you have other more pressing priorities to deal with. The most important thing to consider in this case is that you will have to live with the decision, whether you like it or not. The last thing you want to do is overturn a decision once it has been made. For example, you might let a senior postdoc decide on his or her own whether to collaborate with another scientist or where to submit a paper.

Steps in Making a Decision

1. Determine the type of decision that you need to make.

2. Pick a style that is appropriate for the decision and situation. (Remember, different decision styles will fit different situations and you should be equally comfortable using any of the styles when appropriate.)

3. Make the decision.

4. Keep a log of all your decisions, giving a brief description of the issue at hand, the decision type, and what the decision and outcome were.

5. Go back to the log once a month to see how each decision is playing out.

Depending on your personality, you probably prefer to make decisions in one particular way. For example, if you are an introvert, you may gravitate toward making decisions on your own, without too much group discussion. But people in your lab will appreciate being involved in some of the decisions. It is a good idea to try to experiment with different decision styles in different situations.

Setting and Communicating Rules of Behavior for Members of Your Laboratory

A key aspect of your role as a lab leader is to set and effectively convey expectations that reflect your vision for the lab. Some expectations may apply to a particular group of lab members (e.g., postdocs), and others will be unique to each individual. You may want to work with your lab members to set these expectations—

this can increase the likelihood of buy-in and help increase motivation. The best way to communicate expectations is to convey them continually—at the first interview, on the first day on the job, at lunch time, during lab meetings, and, most importantly, by setting an example. It's also a good idea to communicate your expectations in writing, especially for new lab members and when conducting staff reviews, and to periodically review them with your staff. As a general rule, you should live by the expectations you set for your lab members. Show your workers that you enjoy what you are doing. Especially in the early years, be present in the lab, working side by side with them. They will be able to see how you work and what is important to you.

> *I give a "state of the lab" talk once a year. I start with reviewing the accomplishments, the things that have gone well over the last year. I try to point out things that everyone has done so that there is a sense that everyone has been recognized for their part. Then I go over the lab budget—what our "burn rate" is, where our money is coming from—and talk a little bit about money management issues and strategies.*
>
> —Charles Murry, University of Washington School of Medicine
>
> *We have a package that we give people on arrival that tells them what their lab duties are and how the lab is run. The faster you can get new lab members to the bench and get them going, the better it will be.*
>
> —B. Brett Finlay, University of British Columbia

Below are some general areas that you will want to consider when setting expectations for people in your lab.

Question: How do I avoid potential misunderstandings among lab members regarding work hours and time off?

Answer: The best way to handle this is to convey your expectations about work hours and time off to applicants during the interview. For example, the amount of vacation leave varies from country to country (e.g., it is usually longer in Europe than in the United States), so you should let applicants know about your institution's and your lab's policies.

Work hours. Some PIs feel they should stipulate a specific number of hours per week that they expect graduate students or postdocs to work. But that strategy does not necessarily work well and can generate resentment. Focusing on productivity will prove more successful than focusing on the number of hours or on the specific hours an individual works. Nevertheless, you will probably want the members of your laboratory to be present during certain hours—to make sure that they can interact with you and the other lab members. Generally, your own work

hours set the pace for your group. If you leave the lab at 6:00 p.m., don't expect people in your lab to be working late into the evening.

Prolonged absences. Communicate your expectation that lab members should give you several weeks' notice about an upcoming vacation. Inform them of the vacation and personal leave limits at your institution. Your institution will also have guidelines about maternity and paternity leave. It is best to follow these guidelines rigorously.

> *Some labs get a bad reputation when PIs say, "We expect you to be here every Saturday and never take vacations," or something similar. I think what you want to do is set an example and help your people find how to be most effective. It is possible to work regular hours, but one has to be very organized about it. I have had very efficient people who can be very productive working nine to five and just use their time well. I have also had other people who don't use their time well, and so I try to work with each lab member to help them figure out what works best.*
>
> —Suzanne Pfeffer, Stanford University School of Medicine

Authorship of papers. The inclusion and order of authors on a paper are often sources of discord in the lab. In deciding who should be an author on a paper, the PI has to consider who has contributed to particular aspects of the work. All lab members who are involved in a project should express their expectations concerning authorship and credits on the resulting paper, and provide their rationale for being considered as an author.

Here are some guidelines to consider:

◆   The first author is normally the individual who is primarily responsible for the project.

◆   Occasionally, two individuals may share that responsibility; most journals permit a statement that indicates that the first two or three authors listed have each contributed equally to the publication.

◆   It is unwise to make upfront promises about authorship. You may choose to make it a policy in your lab to wait until you know how much each person has actually contributed before authorship is assigned.

◆   In deciding whether to include someone as an author, ask "Could this project have been done without this person's conceptual or technical contribution?"

> *I have included a student on a paper because he had a conceptual contribution without which the whole study could not have been done. There was no question, everybody wanted this person on the paper—so an author doesn't have to contribute an actual figure if they've contributed something that was essential for that project to go forward.*
>
> —Suzanne Pfeffer, Stanford University School of Medicine

Scientific ethics. The best way to communicate responsible conduct in research to your lab is to live by those values. As a leader, you should talk about important ethical issues (e.g., scientific rigor and reproducible and discrepant results) in a lab meeting or in a more informal setting. Most universities offer lectures or seminars in scientific ethics, and you should encourage your staff to attend. An introduction to the ethical conduct of research is a report from the Institute of Medicine, *Integrity in Scientific Research: Creating an Environment That Promotes Responsible Conduct*, which is available from National Academies Press at *http://www.nap.edu*. You should also make it possible for your research staff to discuss and report concerns to you in a confidential manner.

Project ownership. The PI, with input from individual members, usually decides what projects people in the lab work on. Some labs have strategy discussions every three to four months during which everyone talks about what projects they would like to continue or initiate. Work in the lab is most effective and productive when members have clearly defined projects that are sufficiently distinct so that each person can carry out some independent work, and at the same time the projects are interrelated so that no one is working in a vacuum. This way, everyone in the lab can consult with and motivate each other.

Policy on letting projects leave the lab. You should develop a clear policy concerning whether or not you will allow postdocs to take their projects with them

> *I often encourage people to collaborate or help each other with techniques. So if someone has an idea, I'll say, "Why don't you go to so and so? She has been thinking about that or knows how to use that machine. Why don't you talk to her?" And I try to make it reciprocal as much as I can.*
>
> —Tamara Doering, Washington University School of Medicine

when they leave your lab. Communicate this policy to all prospective postdocs. Some PIs let their postdocs take whatever they had worked on during their stay in their labs, with no strings attached. Others will let postdocs take some aspects of their projects to serve as the focus for their new labs. In these cases, the PI makes sure that he or she does not compete directly with the former postdoc's project for a few years, until the postdoc's lab is well established. When you develop your policy, think about how you would want to handle a situation in which the research results are different from what you anticipated or a situation in which the results lead to interesting new avenues of research. If you have a small research group and a focused area of research, you may not be able to let departing postdocs take their projects with them. In this case, you might have to develop some alternatives to benefit them. One possibility is to give your postdocs six months of salary and resources to generate preliminary data for a new research question or direction. If this is not possible, you may encourage your postdocs to work on two projects: one that contributes directly to the mission of the lab and one that is related to what the lab does but is not a main focus. The postdocs are free to take the latter projects with them.

> *I personally think it's unfair to say to someone who has slaved away in your lab for three years and goes looking for a job, "You can't continue what you've been working on," because then that person won't be able to get a grant.*
>
> —B. Brett Finlay, University of British Columbia
>
> *The head of a lab needs to be generous, and that is hard for junior PIs because you feel like you are just starting and everything is crucial to the success of your research program. So it's hard to let postdocs take projects with them. But they need to, and the main thing is to communicate about it.*
>
> —Tamara Doering, Washington University School of Medicine

Keeping Lab Members Motivated

One of your key roles is to motivate people to work hard toward achieving your shared vision. While different people respond to different types of internal and external motivation, most people are motivated when their contributions to the laboratory are recognized and appreciated. According to Edward O'Neil, to feel motivated, most people require the following:

◆ *Choice:* People want to make some decisions. As a PI, make sure you give people appropriate responsibilities, involve them in discussions about general scientific strategy, and listen to their ideas.

◆   *Competence:* People need the skills to do the work that is expected of them. As a PI, check competences by asking someone to do an experiment with you or ask appropriate questions.

◆   *Purpose:* People need to understand the importance of their role in the lab and in scientific enterprise. As a PI, it is important for you to set goals that define success for each person in the lab and make sure they match with what the person is doing. It is important to listen to what each person wants to do and understand what his or her goals are. If a postdoc has decided to pursue a career in industry, trying to motivate him or her to follow in your footsteps into academia will not work. As a lab leader, you need to address your lab members' individual goals while you work together to realize your shared vision.

◆   *Recognition:* You need to provide continuous feedback to your lab members. Comments and suggestions should be provided in the context of the given expectations. Special accomplishments, such as publishing a paper or getting a difficult technique to work, require special recognition, such as a lab outing.

◆   *Feeling comfortable:* To be able to focus on their work, people have to feel comfortable in their environment. One example is that some lab members like to play music in the lab, while others get distracted by it. The working environment needs to be comfortable so that your lab members look forward to coming to work everyday and enjoy conducting research in your lab with their colleagues.

◆   *Progress:* Satisfaction in achieving goals should not be in the distant future. It is a good idea to schedule individual meetings as often as once a week to set deadlines, solve problems, and plan future experiments.

◆   *Enthusiasm:* You undoubtedly love science for the thrill of discovery, of finding the answer to an important scientific question that has never been answered before—share your enthusiasm and soon others in the lab will follow your lead.

Barring personal problems, when these factors are in place people should feel motivated to work in your lab. A lack of motivation may manifest itself as a decrease in productivity; someone who was productive will stop producing results consistently week after week. You will first need to determine the cause for this decrease. Is it an interpersonal problem in the lab, an experimental obstacle, or a personal crisis? Discuss the problem with the lab member and see whether you can jointly develop a strategy to address the issue or minimize the impact of the lab member's actions.

> *I think the mistake a lot of us make is to assume all too often that individuals don't have any contribution to make, just simply because it might be a minor contribution. I think gaining an appreciation of what everyone brings to the table is extremely important.*
>
> —Gail Cassell, Eli Lilly and Company

> *When people present a really good result at a lab meeting, I'll say, "That seems like a pizza result," and I'll buy pizza for the lab in their honor. Sometimes it's by way of appreciation rather than an important result. If someone—say a junior technician—gets stuck in a cloning project for a long time and then gets the construct he's been trying to make, that's a pizza result.*
>
> —Tamara Doering, Washington University School of Medicine

> *I do half-hour meetings with each person once a week. If they come in and say, "Nothing worked," I say, "OK," and change the subject because I realize that probably 90 percent of the experiments as a scientist don't work. I've found that this approach is a very subtle but effective motivator. Most people don't want to come into my office week after week and say, "Nothing worked."*
>
> —B. Brett Finlay, University of British Columbia

Managing Conflict in the Lab

Conflict is any situation where one person's concerns or desires differ from those of another person. In the lab, conflicts often arise over "turf wars," when two individuals are interested in the same project. By staying on top of what each member of your lab is doing, you can often spot potential problems and deal with them before they become too serious.

Most people tend to avoid conflict. But we should think of conflict as a creative part of our lives. Conflict has the potential of both positive and negative effects. Depending on how it is managed, conflict can be constructive or destructive, be stimulating or unnerving, produce higher-quality results or stifle a project, lead to original thinking or cause destructive power struggles.

Kenneth W. Thomas and Ralph H. Kilmann provide a useful model for evaluating an individual's behavior in conflict situations. The Thomas-Kilmann Conflict Model describes a person's behavior in a conflict situation along two basic

dimensions: assertiveness—that is, the extent to which an individual attempts to satisfy his or her own concerns—and cooperativeness—that is, the extent to which an individual attempts to satisfy the concerns of the other person.

These two basic dimensions of behavior can be used to define five specific modes of dealing with conflict that everyone is capable of using.

Competing. This conflict-handling mode is assertive and uncooperative. Competers pursue their own concerns at the other person's expense. They use whatever powers seem appropriate to win their position, including their ability to argue or their rank. This conflict mode works when you are dealing with a vital issue, an unpopular decision, or a decision that needs quick action. However, although it sometimes seems justified, the mistake many scientists make is to stay in individualistic, competitive mode all the time. For example, if the head of another lab asks you for a reagent that you have not yet cited in a publication and that one of your postdocs is using for his or her project, you may refuse to share the reagent until your postdoc has published a paper referring to it. The decision will probably make you unpopular with the other PI, but you are safeguarding the interests of your postdoc.

Accommodating. This mode is unassertive and cooperative—in other words, the opposite of competing. Accommodators often neglect their own concerns in order to satisfy the concerns of others. Times when the accommodating mode is appropriate are when you want to build political capital or create good will, and for issues of low importance. However, keep in mind that the accommodating mode can be a problem if you keep a tally and expect that the other person will be accommodating next time. For example, you and your collaborator are sharing a piece of equipment that just broke down. He insists that you pay for the repairs since your lab uses it more. You don't agree, but you give in on this one because you know that his lab uses all the other shared equipment more so it will be his turn next time a piece of equipment needs repair.

Avoiding. Avoiders are unassertive and uncooperative. They do not immediately pursue their own concerns or those of others. The conflict is never addressed by avoiders. Many times people will avoid conflicts out of fear of engaging in a conflict or because they don't have confidence in their conflict management skills. But, avoiding can be a good strategy in cases where the person you are in conflict with has much more power than you do or when issues are not that important. It is also a good strategy when you need to buy time. An example of how to do this is to say "These are serious changes. I will need some time to think about it."

Collaborating. This conflict-handling mode is both assertive and cooperative—the opposite of avoiding. Collaborators attempt to work with the other person to find some solution that fully satisfies the concerns of both persons. They dig into an issue to identify the underlying concerns of the two conflicting individuals and try to find an alternative that meets both sets of concerns. With such a positive outcome, some people will profess that the collaboration mode is always the best conflict mode to use. However, collaboration takes a great deal of time and energy; thus, it should be used only when the conflict warrants time and energy. For example, if two postdocs are arguing over "territory," you might want to spend the

necessary time to carefully carve out different projects in a way that will satisfy both postdocs. On the other hand, if your postdocs are in conflict about which day to hold a lab meeting, the time and energy necessary to collaboratively resolve the conflict is probably not beneficial.

Compromising. On the negotiating continuum, this mode lies somewhere between assertiveness and cooperativeness. The goal of the compromiser is to find an expedient, mutually acceptable solution that partially satisfies both parties. The compromiser gives up more than the competer, but less than the accommodator. He or she addresses an issue more directly than the avoider, but does not explore it in as much depth or detail as the collaborator. This mode of conflict resolution is useful for decisions of moderate importance, when you have equal power status, or when you are faced with an issue that needs to be resolved quickly. In general, academics tend to underutilize this mode of handling conflict. For example, say your department chair goes back on her agreement to give you a semester free of teaching responsibilities. She tells you that she is desperate and needs you to teach *Introduction to Biology* for 200 students, including labs during your first semester. You point out that it is stipulated in your contract that your first semester would be free of teaching responsibilities; however, you are willing to teach a smaller, graduate-level course. You of course would rather not teach anything and are not contractually bound to teach your first semester, but you also know that it is in your best interest to accommodate your chair's wishes as much as possible.

Steps for Dealing with Conflict

When faced with conflict:

◆   Assess the problem.

◆   Assess the other person's interests.

◆   Acknowledge the constraints.

◆   Select a strategy that balances the importance of the problem, time constraints, power differences, and the relationships of the people involved.

Each of the conflict-handling modes has value; none is intended to be good, bad, or preferable in all situations. A worthwhile goal for you as a PI is to increase your repertoire of responses to conflict, with the flexibility to use various modes in different situations and in appropriate ways.

The people who work for you in your lab will also tend to adopt one style of handling a conflict over another. You will have a mix of competers, accommodators, and avoiders. Show them by example that there are different ways of handling conflict depending on the situation.

Resolving a conflict between lab members. When conflict occurs between two or more members of the lab, determine whether it is necessary for you to step in and facilitate a resolution. Usually, most people will be able to resolve their own conflicts, but make sure that a conflict does not fester to the point where it affects morale and the atmosphere in the lab.

Here are a few tips for how to help resolve conflict in the lab:

◆   Foster an environment that accepts conflict, as long as the difficulties are faced openly and honestly by the people involved. The PI can actively reinforce openness by lab members, especially the participants in a conflict episode.

◆ Help the individuals involved in a conflict synchronize the timing, focus, and extent of their overtures and responses. The PI may, for example, invite the people involved in a conflict to the office at a designated time to discuss the problems openly and honestly, and come to a resolution.

◆ Make sure that each person understands the other's point of view. The PI can do this by summarizing, clarifying, focusing questions, and encouraging listening by each person.

Resolving conflicts between you and others in the lab. Conflicts between the PI and the lab members also occur. Such conflicts are important and influential in developing the future course of the lab, particularly during the early stages. It is important that the leader demonstrates interest in receiving and understanding negative feedback and shows a willingness to learn from it, when appropriate. It also is important for the leader to avoid the trap of dropping his or her leadership responsibilities and responding to the challenge by becoming "just another lab member." In other words, as a PI, you never have just your interests at hand but those of the lab as a whole.

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APPENDIX 1: THE FOUR PREFERENCES THAT MAKE UP YOUR PERSONALITY TYPE

The Myers-Briggs Type Indicator describes four pairs of opposite behaviors. Everyone prefers one behavior from each pair, and generally uses it more than its opposite.

1. Ways of Gaining Energy

Extroversion. An extroverted individual focuses on the outside world and gets energy by interacting with people and doing things. Extroverts want time to talk, to have something to do, to have a voice, and action.

Introversion. An introverted individual focuses on the inner world and gets energy by reflecting on information, ideas, and concepts. Introverts want time alone, to be asked what they think, thought-out written communication, time to think, and time to assimilate before action.

Example: During a lab meeting extroverts are the ones who tend to talk and ask lots of questions. Introverts are participating just as much, but doing so in their heads. As PI, you will probably need to call on some of the introverts during the meeting to hear their ideas. If you, the PI, are a strong introvert, you may prefer giving feedback in one-on-one meetings.

2. Ways of Gathering Information

Sensing. A sensing individual notices and trusts facts, details, and present realities. Sensing types want concrete data, specifics and details, connections to the past, realistic description of the future, clear guidelines, roles, and expectations.

Intuition. An intuitive individual attends to and trusts interrelationships, theories, and future possibilities. Intuitive types want the overall rationale (big picture), general directions, pictures of the future, and opportunities to participate.

Example: When interviewing candidates for a position in the lab, the sensing PI will have a standard set of questions that he or she goes through with all candidates. The sensing PI will call all the references for each candidate. The intuitive PI, on the other hand, will "know" who to hire after a five-minute conversation with a candidate, regardless of whether or not the candidate has all the necessary qualifications. Both types need to recognize their preferences and take them into consideration. In the interview case, for instance, the intuitive PI should prepare a standard set of questions that are asked of each candidate. On the other hand, once the sensing PI has run through his or her set of already prepared questions, he or she should try to let the conversation wander to learn things about the candidate that could not be gleaned from the list of questions.

3. Ways of Making Decisions

Thinking. A thinking individual makes decisions using logical, objective analysis. Thinking types want to understand the rationale behind changes; have clarity about the decision-making process; understand goals and future structure; and want competent leadership, fairness, and equity.

Feeling. A feeling individual makes decisions by applying person-centered values. Feeling types want to recognize the impact that decisions have on people; to meet people's needs; to include everyone in the decision process; to have values drive change; and to have a leader who cares, appreciates, and supports them.

Example: Most scientists are oriented toward thinking. When making a decision about the best graduate student to take on a project, for instance, a thinking PI would focus on who has the skills to get the project done most efficiently. The feeling PI might also take into account the members' career aspirations as well as lab skills when assigning projects to lab members. Because leadership has a lot to do with relationships, most PIs will find this aspect of their job difficult because they are not naturally oriented toward feeling. Even if it does not come naturally, you can learn to adopt a more people-centered approach.

4. Ways of Living in the World

Judging. A judging individual prefers to be organized and orderly and to make decisions quickly. Judging types want a clear concise plan, defined outcomes and goals, a time frame with stages, clear priorities, completion, and, most of all, no surprises.

Perceiving. A perceiving individual prefers to be flexible and adaptable, and to keep options open as long as possible. Perceiving types want an open-ended approach, general parameters, flexibility and options, information, room to adjust, and a go-with-the-flow approach.

Example: A judging type will meet with the PI and clearly lay out a plan for getting from *a* to *b*, and then spend the rest of the week completing the tasks that were discussed. A perceiving type will see a world of possibilities to discuss at the meeting. With the help of the PI, he or she may be able to come up with a plan of action to get from *a* to *b*, but is likely to get side-tracked and not complete the agreed-upon tasks by the end of the week.

APPENDIX 2: PERFORMANCE REVIEW FORM

Please complete part A in advance and bring it to our meeting or e-mail it to me. We will discuss part B together at our meeting, but you might want to look over the topics.

Part A. Six-Month Review of Goals

Name: _____

Date: _____

I. Accomplishments
II. Goals for the next six months
III. Long-term goals

Part B. Joint-Feedback Meeting

I. Feedback on mentoring
Frequency of interactions
Quality of interactions
Level of involvement
Positive aspects of interactions
Areas for effort/improvement

II. Comments from mentor
Quality of work
Organization and efficiency
Knowledge base
Communication skills
Working relationships
Leadership/supervisory skills
Areas for effort/improvement

III. Summary of discussion
Strengths/achievements
Areas for effort/improvement
Scientific goals
Long-term plans

Lab Director: _____
Lab Member: _____
Date: _____

Source: This form was created by Tamara L. Doering, Washington University School of Medicine.

APPENDIX 3: PERFORMANCE FEEDBACK CHECKLIST FOR MANAGERS

Opening the performance review discussion

Create a sincere, open, and friendly atmosphere. This includes

◆ Reviewing the purpose of the discussion.

◆ Emphasizing that it is a joint discussion for the purpose of problem solving and goal setting.

◆ Striving to put the employee at ease.

Conducting the performance review discussion

Keep the focus on job performance and related factors. This includes

◆ Discussing job elements—employee strengths, accomplishments, and improvement needs—and evaluating results of performance against objectives set during previous reviews and discussions.

◆ Being prepared to cite observations for each point you want to discuss.

◆ Encouraging the employee to review his or her own performance.

◆ Using open-ended, reflective, and directive questions to promote thought, understanding, and problem solving.

Encourage the employee to outline his or her personal plans for self-development before suggesting ideas of your own. In the process, you should

◆ Try to get the employee to set development and improvement targets.

◆ Strive to reach agreement on appropriate development plans that detail what the employee intends to do, a timetable, and the support you are prepared to give.

Discuss work assignments, projects, and goals for the next performance review period and ask the employee to come prepared with suggestions.

Closing the performance review discussion

In closing, you should

◆ Summarize what has been discussed. Pay particular attention to agreed-upon next steps.

◆ Show enthusiasm for plans that have been made.

◆ Give the employee an opportunity to make additional suggestions.

◆ End on a positive, friendly, harmonious note.

Source: This form was developed by HHMI's Human Resources Department.

Chapter 4

STAFFING YOUR LABORATORY

Staffing your lab with the right people is one of the most important things you can do to ensure the success of your research. This chapter focuses on four laboratory positions—technician, postdoc, graduate student, and undergraduate—although much of the material would be relevant for anyone you bring on board. The chapter reviews issues to consider when determining your staffing needs and suggests strategies to help you manage the process for recruiting, interviewing, and evaluating applicants. The chapter also offers guidance on what to do if you have to ask someone to leave your lab.

For a discussion of the skills needed to manage the people in your lab day to day and get them to work productively, see chapter 3, "Laboratory Leadership in Science." Also consult your institution's human resources (HR) staff—they have expertise and resources to help you set performance expectations, maintain performance records, motivate staff and evaluate their performance, deal with behavior or performance problems, and manage issues related to staff promotion and job growth.

GETTING STARTED

The process for staffing your lab will vary depending on the position you are trying to fill and the extent to which your institution's HR department is involved. Because the hiring process in an academic setting can be protracted and time-consuming, you should involve your department's administrative staff or your institution's HR department from the beginning.

Know the Difference Between Employees and Students

It is important to distinguish between employees and students. Generally, technicians and postdocs are considered to be employees of your university or research institution. They receive regular wages and have taxes withheld, and federal and state laws and your institution's personnel policies apply to their employment. On the other hand, undergraduate and graduate students are just that—students. Although they may receive a stipend for work in your laboratory, their relationship to you in almost

all cases is that of learner to teacher, not employee to employer. For the most part, students work in your lab to gain experience and to learn how to do science, not because they receive monetary compensation.

In addition, employees are "hired" and "fired," and students are "assigned" to a lab and "released" from it. Although this may seem like mere wordplay, the nuances of these relationships are important because of the legal implications.

Avoid Discrimination

In the United States, many laws—at the federal, state, and local levels—guide and control how you as the employer's representative work with other employees, particularly those you supervise. These laws determine many aspects of the employer/employee relationship. One very important principle to follow is to avoid discrimination on the basis of an individual's membership in a protected group or an individual's protected characteristic. Generally, this means that you cannot discriminate in an employment-related decision (such as interviewing, recruiting, selecting, hiring, training, evaluating, promoting, disciplining, or terminating) on the basis of someone's race, color, religion, age, sex, national origin, sexual orientation, marital status, mental or physical disability, or other protected status. Work with HR and with knowledgeable people in your department to ensure that you follow the law and your institution's policies and procedures.

Determine Your Staffing Needs

Your decision to take on staff will depend on several factors, such as the provisions of your start-up package, the stability of your external funding sources, the progress of your research, and even your personal preferences about performing various laboratory tasks. Established scientists caution new principal investigators against rushing out and hiring people just to fill an empty lab. Before you bring on staff, think carefully about the consequences. Will you be able to recruit the caliber of people you need? Can you make the time to train and mentor others? Remember, you need to preserve sufficient time and space for your own work at the bench.

Often, the first person a new investigator hires is a lab technician. This versatile lab member can help you with time-consuming initial tasks, such as logging in and setting up equipment and handling routine tasks that keep your laboratory working. Although your budget may more easily accommodate a junior technician, you might

> *Early in my career, when I couldn't attract top postdocs, I put my energy into graduate students and technicians. The graduate students are like raw lumps of clay that have the opportunity to mold themselves into something really great.*
>
> —Thomas Cech, HHMI

benefit more by hiring an experienced technician who can help train other staff as they come on board. Some experienced technicians can also contribute in substantive ways to your research project. A technician who is familiar with the administrative processes of your institution can also be extremely valuable.

Consider bringing a graduate student on board once your lab is running and you have the time to invest in training. Working with your technician and graduate student can provide you with additional intellectual stimulation, and when each is able to work independently, you should have more time for grant writing and doing experiments. Hire a postdoc when your main project is well under way and you have enough other projects, so that you can turn one of them over to the postdoc and allow him or her to have a great deal of responsibility.

You may want to be cautious about taking on undergraduates because of the large time investment needed to make them fully a part of the lab. If you decide to take on an undergraduate, consider limiting the initial assignment to one semester. At the end of that time, determine whether the student should continue for a second semester. (Additional considerations for working with undergraduates and other lab members can be found in chapter 5, "Mentoring and Being Mentored.")

Write the Job Description

The next step is developing a job description for the open position. First, identify and prioritize the initial and ongoing lab tasks for which you need support. Then determine the qualifications needed to best complete these tasks and develop a general plan for allocating the person's time. Most HR departments have job descriptions that you can use as models. Bear in mind that the position will have to fit within your institution's established compensation and classification system. The process may be more complicated if unions represent identified groups of employees at your institution.

RECRUITING APPLICANTS

Get the Word Out

Informal methods. Try to recruit by word of mouth. Ideally, you want people to seek you out. Meetings and seminars where you present your work are good venues to reach graduate students and postdocs, as well as lab technicians who are not employed by your institution. Another strategy is to include a statement on your Web site inviting people to contact you if they are interested in working with you. As you get to know students in your classes, you may find some who are interested in learning more about your work and carrying out a research project in your laboratory. In addition, you may be able to recruit graduate students from those who rotate through your lab as part of the curriculum.

Formal advertisements. To recruit postdocs, you may decide to place advertisements in journals such as *Science* (*http://recruit.sciencemag.org*), *Cell* (*http://www.cell.com*), and *Nature* (*http://www.nature.com*), both in hard copy and on the Web. Other resources for advertising are the Federation of American

Societies for Experimental Biology's Career Resources Web site
(*http://www.faseb.org/careers/careerresources.htm*), your scientific society's Web
site, *Science*'s ScienceCareers.org (*http://sciencecareers.sciencemag.org*), and the
mailing list servers maintained by professional associations, such as the Association
for Women in Science. For any advertisements you place, make sure you follow
your institution's policies.

What Do You Have to Offer?

As a beginning investigator, you may find it a challenge to recruit the people you
want, especially postdocs and experienced lab technicians. Here are some things
you can do to increase your chances:

◆ Promote your vision. When you talk to the applicant, take time to identify
your vision for your lab. Your excitement about your work and your lab will
excite and interest potential staff.

◆ Communicate your lab culture. Think about how to create a lab environ-
ment that allows you and your staff to work efficiently and harmoniously.
If good communication, collaboration, and cooperation are valued con-
cepts in your lab, they can be selling points in recruitment.

◆ Convey your commitment to mentoring. Let potential staff know that they
will be working directly with you and that you have an interest in helping
them in their careers.

◆ Offer flexibility where you can. Flexibility, especially about assignments or
research avenues, is attractive to most job applicants.

◆ Provide a realistic level of reassurance regarding the stability of your fund-
ing. Potential staff are likely to be aware that the money to pay their salaries
may be coming from your research grants.

What *They* Are Looking For

Lab technicians. Technicians may be attracted to a beginning laboratory because
they are eager for the opportunity to work closely with the principal investigator
and are interested in learning new techniques and being included on papers. Good
salaries and status (related to publishing papers) may be of prime importance to
career lab techs, whereas experience, especially experience that will help them
decide whether to go to graduate school or medical school, may be more important
to short-term lab technicians.

Graduate students. Graduate students are often attracted to new labs because, like
lab technicians, they are eager for the opportunity to work directly with principal
investigators. Mentoring graduate students can be time-consuming, especially for
the first few months. Therefore, you may want to sign up your first graduate stu-
dent when your lab is running well and you have time to work with each student
properly. Thoughtful mentoring of graduate students early in your career will help
you develop a positive reputation and will increase your ability to attract other grad-

uate students. On the other hand, if your first graduate students have negative experiences in your lab, they will quickly share this with their peers, and your ability to recruit students will suffer greatly.

> *When I talk to students about what kind of a lab they should join, I always tell them that it's a very special experience to go into the laboratory of someone who is just beginning an independent research career, because the principal investigator is in the lab all the time working shoulder to shoulder with them. There is a lot of excitement and anticipation about exactly which direction the laboratory will go.*
>
> —Thomas Cech, HHMI

Undergraduate students. Undergraduate students may want to work in your lab because they are curious about research, perhaps because they have talked with their peers who are having a good experience in a lab and want to find out whether they should consider graduate study. Or they may be looking for academic credit, funding, or recommendations for graduate or medical school. Try to select undergraduates who are motivated to contribute to the productivity of your lab.

Postdocs. It may take two to three years for you to recruit a postdoc with the desired qualifications. Most postdocs are attracted to more established labs because these usually are better launching pads for their careers. Nevertheless, some postdocs might be attracted by your research area, your concern for furthering their careers, or your institution's reputation and geographic location. If you have a good reputation from your own postdoctoral work, you may be able to recruit highly qualified postdocs right away. Having a policy that allows postdocs to take their projects, or some aspect of their projects, when they leave your lab is also a potent recruitment tool.

SCREENING APPLICANTS

Many principal investigators do all the screening for jobs for which scientific qualifications are important but may rely on HR to do the initial screening for administrative positions. However, as a beginning investigator, you probably will not be swamped with applicants, so you may want to screen all the applicants yourself.

When you review résumés, check skills against qualifications and look for transferable skills. Always review résumés carefully—some applicants may inflate their experience. Gaps in employment and job-hopping may be signs of problems.

Tips for Specific Positions

For an applicant to a postdoc position, consider publication *quality*—not just quantity—and the applicant's contribution. A first-author citation indicates that the applicant probably spearheaded the project. A middle-author citation indicates that the applicant contributed experimental expertise but may have had less to do with the project's intellectual construct. Although it may not be realistic for a beginning investigator, try to find a postdoc with a record of accomplishment—usually two first-author papers—that indicates he or she will be able to obtain independent funding.

If a technician has contributed to publications, you should evaluate them to determine whether the technician has the ability to contribute intellectually as well as technically to the lab. The résumés of less-experienced lab technicians may not show a record of contributions to published papers or other indicators of productivity. Carefully check references to find out about their capabilities.

For a graduate student, speak informally with other people who have worked with the student, including teaching assistants who may know how the student has performed in a laboratory course. Take the student to lunch and see how articulate, bright, and energized he or she is. When selecting graduate students and undergraduates, remember that a high grade-point average is no guarantee of success in your lab.

Check References Directly

For a variety of reasons, including fear of a lawsuit or hurt feelings and concerns about confidentiality, people rarely write negative letters of recommendation. Therefore, you need to contact applicants' references by telephone. You may want to talk with HR in advance about your institution's policies on conducting reference checks.

What to ask a reference. When discussing an applicant with someone who has provided a reference for him or her:

◆ Describe the job and the work atmosphere you want to create.

◆ Ask short, open-ended questions, and avoid asking questions to which the desired response is obvious.

◆ You might want to ask, Why is this person leaving? Is he or she reliable? Would you rehire this person? What are this person's strengths and weaknesses? What are you most disappointed in with respect to this person?

◆ Probe for further information, and ask for examples. Do not settle for yes or no answers.

◆ Try to determine whether your lab values are similar to those of the reference, perhaps by asking about the reference's lab and philosophy. This information should help you decide how much weight to give to the reference.

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Types of Interview Questions

Open-ended questions cannot be answered yes or no; for example, "Tell me about yourself." The applicant determines the direction of the answer.

Directive questions solicit information about a specific point; for example, "What skills do you have for this position?" The interviewer determines the focus of the answer.

Reflective questions solicit information about a past experience that might serve to predict the applicant's future performance; for example, "Describe a time when you demonstrated initiative."

</div>

Contact all references. You are trying to make a decision about someone with whom you will be spending many of your waking hours—make sure you get the information you need. To correct for bias in the responses of any one reference, make sure you call all of an applicant's references, even those overseas. Don't rely on e-mail to make the reference check—you're unlikely to get the kind of information you're looking for.

Sometimes, applicants won't give the name of a current supervisor as a reference. If that is the case, you must respect their request for confidentiality. However, you should probably ask why the applicant doesn't want you to call. You can also ask for additional references who can provide you with information about this person's work habits, accomplishments, and history.

Further Screen Applicants by Telephone

You may want to screen promising applicants by telephone before inviting any of them for a formal interview. As with interviewing references, focus on asking open-ended questions. For foreign applicants, open-ended questions are particularly helpful in determining the person's ability to communicate effectively in English. The appendix (page 96) shows a sample outline that can help you in your phone interviews with applicants. (Consider developing a similar form for talking to applicants' references.)

INTERVIEWING APPLICANTS

Invite Applicants to Visit Your Lab

After you have completed the initial screening, narrow your list of potential applicants to a reasonable number of good prospects. Then, invite each person to visit your lab for a formal interview. Remember, the initial telephone screening interview is no substitute for this in-person interview. (Your institution may be willing to pay the travel costs of applicants for a postdoc position.) In addition to the interview with you, the applicant should meet informally with other members of your lab or, if this is your first hire, meet with your colleagues, perhaps over lunch or dinner. Also arrange for the applicant to spend some time with other lab members and colleagues without you. For a postdoc position, require that each applicant deliver a seminar to members of your lab or department, and then get their feedback.

Share your requirements and expectations for the successful applicant with the other people you have asked to help conduct interviews. This way everyone will be looking for the same attributes and skills.

> *The presentation [postdoc candidates] give to the lab is key. You can check out their ability in public speaking, which is important because in science a lot of times you are a salesperson. I usually try to ask them some decently tough questions—not to try to stump them, but just to make sure that they can think on their feet, because you have to do that a lot as a scientist.*
>
> —B. Brett Finlay, University of British Columbia

Conduct a Structured Interview

The goal of the structured interview is to use a standardized set of predetermined questions to gather key information in an efficient, equitable, and nondiscriminatory manner from all qualified applicants. You want to give each applicant a fair opportunity to compete for the position. Your questions should be

◆ Outlined ahead of time so that you ask basically the same questions of each applicant

◆ Job-related and legal (avoid asking personal questions)

◆ Short and open-ended, like those used when checking references

◆ Focused and designed to elicit information (avoid asking philosophical questions)

Tailor your follow-up questions to reflect each applicant's responses and to encourage each applicant to provide examples from his or her own experiences.

Topics to Avoid

Most illegal or ill-conceived questions deal with race, color, national origin, sex, religion, disability, or age. You should not ask about sexual orientation, marital status, marriage plans, pregnancy or plans for having children, the number and ages of dependent children, childcare arrangements, or other non-work-related matters. Remember that job-related questions are the only appropriate means by which to determine skills and qualifications. Your HR department can provide more guidance on topics to avoid during interviews.

Develop the Interview Questions

As you develop your questions, think about how to determine whether the applicant has the knowledge, technical skills, and personal qualities that you need. Review the job description you created earlier, the applicant's résumé, and your notes from your conversations with the references to identify any items or information gaps that need clarification in the interview.

❝

I ask them, "Why do you want to come to this lab? What interests you? What areas do you want to work in?" I'm looking for people who say they want to broaden their horizons, not those who want to continue doing the same thing.

—B. Brett Finlay, University of British Columbia

❞

Sample interview questions. *At the Helm: A Laboratory Navigator* by Kathy Barker (see "Resources," page 95) contains a list of general questions as well as those geared for specific laboratory positions and for determining specific personal characteristics. In addition, you may want to tailor the following questions to the position for which you are interviewing.

Experience and Skills

◆ Tell me about your most significant accomplishments.

◆ Tell me the part you played in conducting a specific project or implementing a new approach or technology in your lab.

◆ I see you have worked with [insert specific technology or technique]. Tell me about its features and benefits.

Commitment and Initiative

◆ Why do you want to work in my lab?

◆ Where do you see yourself in five years?

◆ What kinds of projects do you want to do? Why?

◆ Tell me how you stay current in your field.

◆ Describe a time when you were in charge of a project and what you feel you accomplished.

◆ Tell me about a project or situation that required you to take initiative.

Working and Learning Styles

◆ What motivates you at work?

◆ Would you rather work on several projects at a time or on one project?

◆ Do you learn better from books, hands-on experience, or other people?

◆ Tell me about a project that required you to work as part of a team. What was the outcome of the team's efforts?

◆ How would you feel about leaving a project for a few hours to help someone else?

◆   If you encountered a problem in the lab, would you ask someone for help or would you try to deal with it yourself?

◆   You may be asked to work after hours or on a weekend. Would this be a problem?

Time Management

◆   How do you prioritize your work?

◆   What happens when you have two priorities competing for your time?

Decision Making and Problem Solving

◆   What is your biggest challenge in your current job? How are you dealing with it?

◆   Tell me about a time when you made a decision that resulted in unintended (or unexpected) consequences (either good or bad).

◆   Give me an example of a situation where you found it necessary to gather other opinions before you made a decision.

Interpersonal Skills

◆   How important is it to you to be liked by your colleagues and why?

◆   If you heard through the grapevine that someone didn't care for you, what would you do, if anything?

◆   Tell me about a situation in which your work was criticized. How did you rectify the situation?

◆   Describe a scientist whom you like and respect. What do you like about this person?

Cultural differences. You may find yourself considering applicants from different cultures whose beliefs, such as those about self-promotion, collaboration, and deference, may differ from the beliefs commonly held in the United States. To learn more about cultural factors, see chapter 5, "Mentoring and Being Mentored." To ensure you are considering all candidates fairly, refer to Kathy Barker's *At the Helm: A Laboratory Navigator*; in that book the author provides a list of useful questions you might ask a candidate, including the following:

◆   How do you feel about getting in front of a group and describing your personal accomplishments?

◆   How would you respond if a more senior lab colleague took credit for your project?

◆   If you did not understand something, would you persist in asking for help even if the principal investigator got annoyed?

My favorite questions are, "What do you want to be doing five years from now? Ten years from now? What area do you want to be working in?" These give me an idea of just how mature [applicants]are in terms of how much they have thought about what they want to do and how committed they are.

—Gail Cassell, Eli Lilly and Company

Tips for Conducting an Interview

◆ Before you begin, try to make the applicant feel comfortable. Make appropriate small talk, offer a beverage, and compliment the applicant on making it thus far in the selection process. Remember that the applicant is also deciding whether he or she wants to work for you.

◆ Develop professional rapport, but avoid a social atmosphere:

Explain how the interview will be structured.

Briefly describe the selection process.

Outline the responsibilities for the open position.

Convey your expectations about the job. Include values that may seem obvious to you, such as your commitment to lab safety and scientific rigor.

Keep in mind the topics to avoid.

◆ Take brief notes. Record actual answers to questions, not evaluative or conclusive comments.

◆ Listen carefully. Let the applicant do most of the talking.

◆ Develop a high tolerance for silence. Give the applicant a chance to think and develop thoughtful answers to your questions.

◆ Give the applicant many chances to ask questions. This will give you some insight into what is important to him or her.

◆ Never make promises or give commitments, even those that seem innocent to you.

◆ Ask the applicant about his or her timetable for leaving the current job, even if you asked it during the telephone interview.

◆ Before ending the interview, do the following:

> Give the applicant a chance to add anything else he or she thinks may be important for you to know in making your decision.
>
> Make the applicant aware of the next steps, such as additional interviews and the time frame for hiring.
>
> Thank the applicant for his or her time.

Special Considerations

This section is especially relevant for interviewing technicians, postdocs, and other professional laboratory staff.

Pregnancy. If, during the interview, a well-qualified applicant tells you she is pregnant, remember it is illegal to discriminate against someone because she is pregnant. Familiarize yourself with your institution's policies on maternity leave before making any statements to the applicant about what length of maternity leave would be permitted and whether the leave would be paid or unpaid. Similarly, your institution may have a policy on paternity leave that may apply to an applicant.

Visas. If you are filling a postdoc position and are dealing with foreign applicants, remember that visa rules and requirements are complex and change frequently. Some visa types are more desirable from the perspective of the applicant (e.g., because they allow for concurrent application for permanent residence in the United States). Other visa types are more desirable from the perspective of the employer (e.g., because they are easier to administer). Special concerns for any type of visa may include visa arrangements for a spouse and other family members, requirements to return to the home country, and employment implications. Keep in mind that obtaining a visa can be a very slow and lengthy process. (Obtaining visas to travel to the United States has become even more time-consuming given increased U.S. security concerns and clearance.)

Consult HR, your institution's international office, and your department's administrative staff about visa rules and requirements. They can also help you determine which visa is most appropriate for a given applicant. You can also check the latest information from the State Department (*http://travel.state.gov/visa/visa_1750.html*) and the U. S. Citizenship and Immigration Services (formerly the Immigration and Naturalization Service, *http://www.uscis.gov/graphics/index.htm*). The site *http://www.visalaw.com* may be helpful. A brief visa primer also is available in *At the Helm: A Laboratory Navigator* by Kathy Barker.

In addition, try to determine the consequences (for you as well as the applicant) if poor performance forces you to ask the postdoc to leave your laboratory. Because this is an extremely complex area of immigration law, it is important that you consult your institution's HR or legal department and follow their advice.

EVALUATING APPLICANTS

Before you begin evaluating an applicant, make sure that you have all the necessary information. Conduct any reference interviews that you were unable to complete before the interview. Gather opinions from others who have met with the applicant. As needed, seek guidance from your department and HR.

Maintaining Objectivity

As in any situation that involves interpreting interpersonal behavior, objectivity in evaluation may be difficult. Nevertheless, try to avoid the following:

◆ Relying too heavily on first impressions.

◆ Making a decision too early in the interview, before asking all questions.

◆ Downgrading an applicant because of a negative characteristic that is not relevant to the job itself.

◆ Allowing a positive characteristic to overshadow your perception of all other traits, sometimes called the "halo effect."

◆ Judging the applicant in comparison with yourself.

◆ Comparing applicants with one another rather than with the selection criteria (e.g., if you have been interviewing poorly qualified applicants, you may rate average applicants highly).

◆ Allowing factors not directly related to the interview to influence your estimation of the applicant (e.g., interviewing during times of the day when you may be tired).

What to Look For

In addition to determining whether the applicant has the qualifications required to perform well in your lab, you should also keep the following points in mind:

◆ Consider the "chemistry." First and foremost, pay attention to your intuitive reaction to the person. Look for a person who is interested in, and able to get along with, others.

◆ Ascertain whether the applicant is a good fit. Keep in mind that you are building your team and need people with the skills and personalities to get things done. Look for people who have a track record of productivity and have demonstrated an ability to learn new skills.

◆ Seek someone who has a passion for science and a strong work ethic. Enthusiasm, a can-do attitude, and the willingness to go the extra mile are critical attributes.

◆ Check the applicant's career plans. Knowing what the applicant wants to be doing in 5 or 10 years can give you insight into his or her scientific maturity and creativity, as well as his or her commitment to a specific research area.

◆ Be certain the applicant is committed to good research practices. Record keeping and reporting results are even more important now than in the past because of patent and other legal issues. Insist on the highest level of scientific integrity from anyone you are considering.

> *If people in the lab had reservations about whether they would get along with someone, I probably wouldn't bring that person in.*
>
> —Tamara Doering, Washington University School of Medicine
>
> *If people don't seem like they would be fun to work with, I would use that as a reason to turn them down. Even if they have a lot of papers and seem to be very smart, I think you might want to think twice about hiring them.*
>
> —Thomas Cech, HHMI

Red Flags

Warning signs during an interview that should alert you to potential problems include:

◆ Unwillingness to take responsibility for something that has gone wrong.

◆ Complaining about an adviser and coworkers.

◆ Demanding privileges not given to others.

◆ Delaying answering questions, challenging your questions, or avoiding answering them all together. (Humor and sarcasm can be tools to avoid answering questions.)

◆ Unless you have been rude, responding to an interview question with anger is never appropriate.

◆ Incongruence between what you hear and what you see (e.g., downcast eyes and slouching are not signs of an eager, assertive candidate).

◆ Trying to control the interview and otherwise behaving inappropriately.

MAKING THE OFFER

This section is especially relevant for hiring technicians, postdocs, and other professional laboratory staff.

Before you make an offer, check with your department to learn which items of the job are negotiable and whether you are responsible for negotiating them. HR or your department should provide you with institutional salary ranges for the position. In some institutions, HR will determine the initial salary that you can offer. In other institutions, you may be given some leeway within a predetermined range that is appropriate for the job description.

Once you have identified the person you wish to hire, contact him or her by telephone to extend the offer and to discuss start date, salary, and other conditions of employment. (Be sure to check with HR first to determine whether you or they will make this contact and cover these issues.)

Inform All the Applicants

First, inform the person you have selected. If he or she turns down the offer, you can move to your second choice.

Once you have filled the position, let the other applicants know. You do not need to give a specific reason for your decision not to hire an applicant. However, you may state that the selected candidate had better qualifications or more relevant experience or that it is your policy not to disclose this information. Check with HR and your department's administrative staff about policy in this area.

The Offer Letter

After you and the selected candidate have confirmed the job details via telephone, your institution will send the formal offer letter. Usually, it confirms the offer terms, including start date and salary. Coordinate with HR and your department's administrative staff to determine what information to include.

An offer letter to a foreign national may need to include more information. For example, it may need to spell out that employment is contingent on the ability to obtain authorization for the individual to work in the United States and to keep the work authorization in effect. HR or your department's administrative staff will help you follow policies correctly in this type of situation.

ASKING STAFF TO LEAVE

Despite all your best efforts, you may need to ask someone to leave your lab. Before considering dismissal, be sure that you have tried various avenues to help this person be successful in your lab. This may include assistance with scientific techniques and counseling for behavioral issues. Also, be certain that your dissatisfaction is based on objective observations, not your personal biases.

Try to determine whether you think the person would be better off in another lab or should consider another career. For students and postdocs, this usually means talking with that person and his or her faculty adviser or the graduate student committee. It may be best to suggest to someone that research is not for them if you truly believe the profession is not suited to his or her talents or personality. You can provide that person with encouragement and options. For example, *Science*'s ScienceCareers.org Web site provides a range of career options for people with bio-science backgrounds (*http://sciencecareers.sciencemag.org*).

There are no hard and fast rules about how a manager should address performance or behavior problems in the lab. However, keep in mind the following, especially if you're thinking about letting someone go:

◆ Be fair.

◆ Let there be no surprises.

Fairness dictates that lab members receive some type of notice about unsatisfactory performance. Make sure the person knows your concerns and is given a reasonable opportunity to respond and turn things around.

Keep a Record

You should outline and set expectations for the performance and conduct of everyone in your lab. The process is more formal for employees than it is for students.

For technicians, postdocs, and other professionals, job expectations should be made clear. Don't expect your employees to read your mind about what you want them to accomplish and how you want them to accomplish it. Keep good records of your conversations with everyone so that you can track your own efforts and determine whether your staff has met expectations. If a lab member is not meeting expectations, make sure you document your attempts to help the person improve his or her performance or prepare for a new career. Should you ultimately have to terminate this person, these records can help avert external challenges to your decision.

> *When postdocs don't fit in, I try to help them find other positions. Sometimes they realize that this isn't where they belong and they do it themselves. I say, "What do you want to work on? Let's see what we can do." People are different, sometimes things don't work out, and this is not a reason to be defensive. The focus is to help people do what they value.*
>
> —Suzanne Pfeffer, Stanford University School of Medicine

Deliver a Warning

Warnings should be delivered by you, calmly and in private. Listen to the employee's point of view and explanation. Develop a plan for addressing the problem with benchmarks and timelines. You may want to commit your action plan to writing. If you provide advance notice, employees will not be surprised when you take forceful action concerning unsatisfactory performance or behavior.

If You Decide to Terminate

An employee with serious work-related problems is a disruptive force and, especially in a small lab, can significantly retard research progress. Although it is not easy to decide to terminate someone, those investigators who have had to release staff say that in retrospect their biggest mistake was not doing it sooner.

To be fair to yourself and your staff and to avoid lawsuits, an involuntary termination should never happen out of the blue unless it is the result of substantial misconduct, such as clear fraud or violence in the workplace. Always avoid firing on the spot. You should find a way to calm the situation so that you don't take precipitous action. A suspension with or without pay may be a good option for the short term while you consider the situation. If you have decided that termination is your only solution, consult with HR as soon as possible to ensure that you are complying with institutional and legal requirements relating to termination and correctly documenting your actions.

Questions to ask yourself before letting someone go. HR professionals recommend that, if circumstances permit, you ask yourself the following questions and document each of the actions before proceeding:

◆ Have you given the person at least some type of notice or warning?

◆ Have you made it clear to the person what he or she is doing wrong?

◆ Has the person received counseling or assistance in learning new or difficult tasks? If so, how much?

◆ Are you treating (or have you treated) the person differently from other staff in your lab?

◆ Are you following written procedures and institutional policies?

◆ Does the documentation in the personnel file support the reason for discharge?

Ideally, you have conducted regular and candid performance reviews with all your laboratory staff and now can use this documentation to help support your decision. (For a discussion of conducting performance reviews, see chapter 3, "Laboratory Leadership in Science.")

How to terminate. Terminating anyone from your lab is a confidential matter and should not be discussed, before or after the fact, with others in the lab. A termination meeting should be conducted by you, the investigator, in your office, in a way that is private and respectful. (You can always ask HR for assistance if you are unsure how to proceed or if you suspect that your employee may act inappropriately.)

Prepare for the meeting. Develop a script and practice it until you can convey the information confidently. Keep in mind that what is said during the termination meeting can become part of the basis for a subsequent challenge. Remember to

◆　　Be polite.

◆　　Stay focused on the issue at hand. Get to the point quickly. Explain the decision briefly and clearly. Don't apologize or argue with the employee in an effort to justify your decision.

◆　　Avoid laying blame.

◆　　Arrange to have scientific materials and equipment and supplies returned to you, including lab notebooks; protocol books (unless it is a personal copy); lists of clones, cells, and experiments in progress; and keys.

◆　　Let the employee have an opportunity to have his or her say, and pay close attention to what is being said.

◆　　Refer the employee to HR or to the office responsible for discussing benefit eligibility.

◆　　Take notes that document this meeting and convert them into an informal or formal memo to file.

◆　　Try to part on cordial terms. Science is a small community, and your paths may cross again.

Termination letters and references. As part of final documentation, a termination letter may be required by your institution or by state law. In addition, you may be asked for, or may wish to offer, a reference. Check with HR about proper procedures.

Visa considerations. Consult with HR or your department's administrative staff about visa issues before terminating a foreign national employee. Be certain that you are not legally responsible for continuing to pay the salary of someone no longer working in your lab. Again, it's better to understand these requirements before you hire someone with a visa.

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APPENDIX: TELEPHONE INTERVIEW OUTLINE

Date: _____

Candidate: _____

Investigator's Questions (Use open-ended questions, and ask for examples.)

To see if we might fit, give me an idea of what you are looking for.

What are your goals for this position? (short-term expectations, long-term plans)

Tell me about yourself as a scientist:

- ◆ What are your strengths?
- ◆ What are your weaknesses?
- ◆ What do you want to learn?
- ◆ What are you looking for in a supervisor?

What is your preferred interaction style? (with me, with others, on joint projects)

Timing, current job

Visa status

Investigator's Comments

Background, interests, goals

The projects we are working on

What I am looking for

What I expect (enthusiastic, interested, communicative, a hard worker, responsible)

What I will offer (be there, help, communicate, support career with communication about goals, funding for x amount of time)

The university, department, town

Timing, constraints

Source: This interview form is adapted from one developed by Tamara L. Doering, Washington University School of Medicine.

Chapter 5

MENTORING AND BEING MENTORED

As a principal investigator, you probably will hire technicians, assume responsibility for the direction of graduate students, and take on a few postdocs. In addition, your undergraduate students may look to you for guidance about careers in science. It's also possible that young scientists outside your lab may begin knocking on your door. Each of these individuals may look to you as a mentor. At the same time, you will continue to be in need of guidance for your own continuing professional development. This chapter describes the process of mentoring, with the focus on mentoring the people working in your lab. It also suggests desirable personal qualities and plans of action for both mentors and trainees. (Note: In this chapter, the people you mentor are referred to as "trainees," although not everyone you mentor may be receiving training in your lab.)

WHAT IS MENTORING?

Scientific mentoring is a personal, one-on-one relationship between a more experienced scientist and a junior scientist or a scientist-in-the-making. The mentor is exposed to the trainee's energy and ideas, and the trainee receives the guidance and encouragement necessary for professional development. Mentoring relationships commonly form across broad experience gaps—e.g., professor to student—but also can be established between peers or near peers. For example, a graduate student whose background is in biology may serve a laboratory mentoring role for a graduate student whose background is in mathematics, or a graduate student may mentor an undergraduate.

Mentors usually include those who are officially responsible for the work of junior scientists or students, such as the principal investigator or a formal adviser. However, it's also important to have mentors who are outside the direct line of authority. These mentors can be especially helpful in providing guidance when formal advising relationships become strained or when the personal or professional interests of the trainee differ from those of the formal mentor.

Not only does mentoring benefit the trainee, it also benefits the mentor. As a mentor, you derive personal satisfaction in helping nurture the next generation of scientists.

Your scientific achievements are carried forward by those you have mentored. As your trainees embark on new projects, you are naturally kept abreast of the latest scientific developments. In addition, your professional network expands as your trainees expand their professional horizons.

Traits of a Good Mentor

Good mentors often share some of the following personal qualities:

◆ *Accessibility:* An open door and an approachable attitude.

◆ *Empathy:* Personal insight into what the trainee is experiencing.

◆ *Open-mindedness:* Respect for each trainee's individuality and for working styles and career goals different from your own.

◆ *Consistency:* Acting on your stated principles on a regular basis.

◆ *Patience:* Awareness that people make mistakes and that each person matures at his or her own rate.

◆ *Honesty:* Ability to communicate the hard truths about the world "out there" and about the trainee's chances.

◆ *Savvy:* Attention to the pragmatic aspects of career development.

Confidentiality in Mentoring

As a mentor, you may be privy to a lot of information about your trainees, from their past professional accomplishments and failures to their personal relationships and financial situation. You should treat all information as confidential. Your trainees should feel that they can trust you with whatever problems they share with you.

A MENTOR'S RESPONSIBILITIES

Mentoring entails substantial commitments of time, energy, and good will. A significant portion of your time must be allocated to each trainee, and you must be prepared to obtain the resources the trainee needs. In addition, you should use your experience and contacts to help the trainee establish a professional network.

Question: How do I say no to being someone's mentor?

Answer: Be kind: Imagine yourself in your requestor's shoes. Listen to them intently and give reasons related to your own limitations. However, be clear and firm. Do not invite misunderstanding. Suggest alternative sources of help, but check first with the potential mentor.

Choosing Whom to Mentor

You will have to make case-by-case judgments about which mentoring relationships you can afford to enter into and how intensive each one should be. There are some people for whom you are clearly responsible, such as the people working in your lab. The students in your courses also have legitimate expectations of you. Others, outside your lab or courses, may come to you for advice.

Some people are more promising than others, and you want to nurture their talent. Others have interests closely related to yours, and it is natural for you to want to work closely with them. Still others show promise but are needy in some respect; for example, their skills are not fully developed or they need help focusing their efforts. With the people in your lab, the important thing is to be fair and avoid favoritism. With the people outside your lab, you need to avoid overextending yourself or setting up expectations you can't fulfill.

Defining Your Role as a Mentor

Generally speaking, a mentor provides whatever is needed to further a trainee's professional development but is not necessarily a friend. You should offer to teach technical skills, give advice about the political aspects of science, and suggest networking opportunities, but you should probably not offer advice on personal matters. Often, emotional issues are relevant to one's work, and you can offer moral support, but a good mentor treads carefully.

> *One of the lessons is that my job is not to be their best friend. My job is to be their mentor, and my job is to be their boss or supervisor.... I had this sort of egalitarian thing where I was trying to run a professional laboratory, but I was also wanting to be buddies with everybody.... I have come to realize the alternative—to have a little distance. Things work better if it's clear that I am the head of the lab.*
>
> —Charles Murry, University of Washington School of Medicine

Mentor Versus Adviser

In theory, mentors have multiple responsibilities—being an adviser is one of these. According to the Council of Graduate Schools (*http://www.cgsnet.org*) mentors are

- ◆ *Advisers:* People with career experience willing to share their knowledge.

- ◆ *Supporters:* People who give emotional and moral encouragement.

- ◆ *Tutors:* People who give specific feedback on one's performance.

- ◆ *Masters:* Employers to whom one is apprenticed.

- ◆ *Sponsors:* Sources of information about opportunities and aid in obtaining them.

- ◆ *Models of identity:* The kind of person one should be to be an academic or a professional scientist.

In reality, it is unlikely that any one individual can fulfill all possible mentoring roles. For this reason, many argue that the term mentor should be used broadly to mean an individual who helps another with one or more aspects of his or her personal or professional development or both. In this sense, trainees are encouraged to seek out various faculty who can provide some of these components.

STRATEGIES FOR EFFECTIVE MENTORING IN YOUR LAB

Make Everything a Learning Opportunity

It helps to think of mentoring as a highly individualized mode of teaching. You want to establish a "culture of teaching" in your lab, so that each individual feels empowered to seek whatever he or she needs to do good science.

Set Specific Goals and Measures of Accomplishment

Work with each individual—at performance evaluation time, in the course of lab meetings, and on other occasions when his or her work is under review—to set specific goals and measures of accomplishment. The following are some examples:

◆ For a postdoc or student, you might want to establish a publishing goal. It should include deadlines.

◆ For postdocs, job-hunting goals might be important. You might say, "By next month, give me your list of places you want to apply to. Then we can talk about developing your job talk."

◆ Have technicians identify new skills they need (e.g., using new equipment or software). Give them time to learn and the opportunity to take courses or seek help from others. Then ask them to demonstrate what they have learned at a staff meeting.

In some cases, you may have to push people a bit to set their goals. In other cases, people's goals may be well-defined but may not exactly fit your lab's overall goals. If you can, give them room to explore options, and offer whatever educational and networking opportunities you can afford. They will be much happier and more productive while they are with you if they feel you are looking out for them and their future well-being.

Encourage Strategic Thinking and Creativity

Trainees in your lab, especially newcomers, may not have the experience to judge how long to struggle with an experiment or a project that is not working. As the principal investigator, you must decide what work is most important, how long a given project can be pursued, and what resources can be allocated to any particular effort. As a mentor, you should explain the basis and significance of your decisions to your trainees. In this way, you give concrete examples of strategic thinking and prepare your trainees for similar decisions they must make when they are in charge of their own research programs.

It is also important to give people enough space to be creative. Don't rush in too quickly with interpretations of data or solutions to problems. Let your staff take the first stab. Be thoughtful and ask probing and guiding questions. By doing this, you prepare your trainees to work through projects independently and you benefit from their insights and creativity.

> *If you just regiment the students' and postdocs' lives, you may have a very productive laboratory, but you may miss out on an opportunity to stumble on a major discovery or new scientific direction.*
>
> —Thomas Cech, HHMI

Uphold Professional Standards

Those new to research are still forming their professional standards and habits. They will be working with you for months or years and will learn your lab's way of doing things. Set high standards for yourself and your workers, and make sure your lab offers an encouraging and disciplined environment. Experienced lab leaders list the following essentials:

- ◆ Encourage good time-management techniques. At the same time, respect individual patterns of work. (See chapter 6, "Time Management.")

- ◆ Clearly state your expectations. Let people know when they are not meeting them. (See chapter 3, "Laboratory Leadership in Science.")

- ◆ Offer criticism in a way that doesn't shame and discourage people.

- ◆ Keep abreast of laboratory record keeping. This is a key management responsibility and an aspect of mentoring. As the principal investigator, you are responsible for seeing that your people keep meticulous records documenting their work and meeting regulatory requirements. This habit will serve them well later on. By reviewing lab notebooks frequently, you also guard against falsification of data. (For more on record keeping in the laboratory, see chapter 8, "Data Management and Laboratory Notebooks.")

Impart Skills

Do the following to encourage your lab workers to learn new skills:

- ◆ Involve everyone in the scientific publishing and grant-writing process. Part of your job is to teach your trainees how to write publishable scientific papers and successful grant proposals. For papers, have the first author write the first draft, and then send the paper around the lab for review. For proposals, have each person write a piece of the proposal, and then have everyone review successive drafts of the whole package. By doing this,

everyone will gain invaluable experience and get a chance to see the big picture of the lab's activities.

◆   Impart technical skills. As a manager, you need to know the skill sets of each member of your lab and make sure that each important skill is passed on to several people in the laboratory, for their benefit and yours.

◆   Teach lab management explicitly. Give the people in your lab managerial responsibilities; for example, have them coordinate the sharing of equipment in the lab or draw up a list of routine lab jobs that can be rotated among lab members.

> *I have a graduated system for providing opportunities. For example, [graduate students and postdocs] must write their own meeting abstracts and papers. They must present at lab meetings and seminars in the department when works are published. If they go to meetings, they must provide meeting summary presentations when they get back. If they do well at these tasks, I let them review manuscripts with me, providing comments that I may choose to incorporate into the final review. The ultimate compliment is when I ask them to attend meetings on my behalf.*
>
> —Milton Datta, Emory University School of Medicine

Provide Networking Opportunities

One of the most important benefits you confer on the people you train is admission to the network of scientists in your field. Your reputation opens doors for those associated with you, and the connections are not likely to be made without your involvement. So take steps to facilitate the introductions, including

◆   Allowing trainees to meet with seminar speakers invited to your institution.

◆   Taking trainees with you to meetings and introducing them to your colleagues.

◆   Encouraging trainees to approach your colleagues about scientific matters, using your name.

◆   Encouraging trainees to make presentations at meetings when they are ready.

Give Moral Support

You can help the people you mentor estimate their own potential and chart their life course. To do so, you must be supportive and honest. Try to convey to each of your trainees that you have a commitment to him or her and that when a problem surfaces, you have an interest in helping to solve it and will do everything you can to do so.

DIFFERENT MENTORING NEEDS

Each type of lab worker—for example, undergraduate, graduate student, postdoc, and technician—is on a different professional trajectory. As you work with them, you need to keep in mind their path and their location on that path.

Mentoring Undergraduates

The seeds of a scientific career are planted in the undergraduate years or even earlier. Promising undergraduates can be invited to take part in research through academic independent-study options or can be given paid work. Take their work seriously, and set high standards for them. You might place them under the day-to-day guidance of a graduate student or postdoc, but you should maintain a strong role in overseeing their training and the overall flow of their work within the lab. Keep in mind that these beginning researchers may need extra encouragement when their research isn't going smoothly.

Mentoring Graduate Students

In science as in other fields, graduate school is vastly different from the undergraduate scene. Perhaps the most important difference is that undergraduates are expected to be primarily engaged in absorbing knowledge, whereas graduate students are expected to begin making their own contributions. A mentor helps new graduate students make this transition. A graduate student may have several mentors, but the most important is the principal investigator in whose lab the student is working.

A typical graduate student follows this trajectory:

First years. The principal investigator's task is to provide a focus—a coherent plan of study. The student faces a steep learning curve. Basic techniques must be learned, comprehensive exams taken, and a thesis topic chosen. The principal investigator keeps tabs on the student's progress. The student's success depends on effective mentoring by the principal investigator.

Middle years. At some time during these years, the student may be struggling with his or her thesis. The principal investigator helps the student out of a slump by offering moral support and suggesting ways to tackle a scientific problem. By now, the student has learned a lot and should be sharing information and techniques with colleagues, younger students, and postdocs. Teaching others is a good way to learn.

Final years. The student is preparing to move on. The thesis should be near completion, and the search for a postdoctoral position should be under way. The principal investigator will be asked for letters of reference and perhaps more active job-hunting assistance. Other mentors, such as members of the thesis advisory committee, may be called upon for help in the job search as well.

Mentoring Postdoctoral Fellows

Postdocs are in transition. On the one hand, they are highly trained professional scientists who are working in your lab for a limited time to conduct research within the general parameters of your and their shared interests. On the other hand, they are not really complete professionally, because a stint as a postdoc is usually a prerequisite for an academic position. Your task as a mentor of postdocs is therefore complex.

Keep in mind that the amount of time you can spend helping your postdocs will be limited, so use that time efficiently. In addition, find ways to have them help one another or obtain assistance from other sources.

You must strike a delicate balance in directing postdoctoral work. Although the postdocs may be working on your projects, you must treat them as collaborators, not employees who require close supervision. Encourage them and give them the help they need in setting research and career goals, but give them sufficient independence so that they "own" their projects.

You do have a protective function when it comes to the politics of the larger academic world. Your postdocs are young, politically inexperienced, and vulnerable. You need to be aware of outside competition. Be prepared to steer your postdocs away from projects that might result in conflict with researchers who are already working on similar projects and who might publish results before your postdocs are able to.

If a postdoc is not working out as you had hoped, encourage him or her to make a change. You may be able to help the postdoc find a more suitable position. But even if you can't, an unhappy postdoc should move on sooner rather than later. (See "Asking Staff to Leave," page 91 in chapter 4, "Staffing Your Laboratory.")

As with all trainees, it is important to discuss career goals with your postdocs. Not all will be interested in or competitive for academic positions. For those who are, help them develop a project that they can take with them after they leave your lab and begin to establish their own labs. Alternatively, you can let your postdocs take a project from your lab with them and work on it for a specified time period (e.g., for several years) without competition from you, with the understanding that when that period has passed, your lab may pursue research in the same area.

You have a huge role to play in facilitating your postdocs' job hunts. Keep alert to job openings, counsel them about the process, coach them in their interview presentations, and give them the best letter of recommendation you can. Sometimes, when the search doesn't go smoothly, you may need to keep them in your lab a little longer than you expected. Keep up the words of encouragement during this difficult period. After they have gone, keep in touch with them. They will be an increasingly important part of your professional network.

Mentoring Technicians

A technician is your employee, hired to get work done. That being said, many technicians are a distinct type of professional scientist. You should understand and encourage their aspirations. Make it clear to them that they are valued contributors to your projects. If they are interested, you may want to give them research projects of their own. If their aspirations are purely technical, encourage them to gain new skills.

Special Issues for Physician-Scientists

How to Mentor Physician-Scientists

Physician-scientists have an especially complicated balancing act: caring for patients, carrying out experiments at the bench, and meeting regulatory requirements for human-subjects research. As a result, they may not be able to spend as much uninterrupted time in the lab as their Ph.D. colleagues. However, the strength of physician-scientists is that they have a clinical base. As a mentor, you should understand the unique challenges physician-scientists face, as well as value their strengths. Help physician-scientists in your lab with establishing priorities and developing effective time management skills. If you are not a physician-scientist, put them in touch with someone who can help them with these competencies. In addition, encourage physician-scientists in your lab to use their clinical base. For example, they might enroll patients from their clinic or practice following a simple protocol. They might collect answers to a questionnaire with demographics, or obtain data on clinical presentation, progression and response to therapy, as well as collect relevant serum or tissue samples. Even if you do not have use for these specimens, if they are well-collected and from well-defined sources, then they will have value to someone, perhaps a colleague in your department, who is testing a particular hypothesis. Making use of the physician-scientist's clinical base can compensate for the split in time. In addition, clinical work allows physician-scientists to sometimes see connections that someone with narrower training may not see. As a mentor you should take advantage of this perspective. Make sure that questions about clinical translation or relevance are brought up in the lab and directed to the physician-scientists.

MENTORING INDIVIDUALS OUTSIDE YOUR LAB

When you get a request for mentoring from a young scientist in another lab, or even in another university, think carefully before you agree. Do not enter into such a relationship secretly. Insist that the individual inform his or her principal investigator that you two are speaking. On the one hand, the request says something positive about your standing in the research community. In addition, by taking on a new relationship, you might open up the possibility of future collaborations. On the other hand, there may be problems you are not aware of. Ask yourself the following questions:

◆ Why is this person asking me for help? There may be a negative reason. In the case of a postdoc, perhaps he or she is dissatisfied with relationships in the home lab. If this is the case, make sure you are not offending the indi-

vidual's principal investigator. You may find that the other principal investigator welcomes your help as an extra resource.

◆   What are the person's expectations? You need to be clear about whether you are being asked for occasional advice or long-term assistance. If it's the latter, determine whether your mentoring role will be formal or informal.

◆   Do I really have the time and energy to commit to this relationship?

◆   Is this someone I want to mentor?

The people in your lab deserve priority. But if the person fits, and you can extend yourself, do so.

HOW TO GET THE MENTORING *YOU* NEED

Being mentored is as much an art as mentoring. It's a matter of getting plugged in to a complex network, knowing whom to ask for what, knowing how to accept the professional advice you receive, and maintaining long-term personal and professional relationships. The following suggestions may help:

◆   Don't let go of your old mentors. Stay in close touch with your graduate and postdoc advisers. Although they may not be familiar with your new environment, their distance from it, combined with their general understanding of the world of science, can help you put your current environment in perspective. Also, you never know when you will need to ask them for a reference or other professional help. Even a quick e-mail to let them know that you published a paper or received a research grant or an award will help them support your career.

◆   Establish a relationship with a set of official mentors. Your new department probably will assign you a mentor or even a mentoring committee. These individuals may ultimately constitute your promotion and tenure committee, so cultivate them carefully and treat them with respect. You do not want to vent your frustrations or confide your uncertainties and weaknesses to this group.

◆   Seek out informal mentors. These usually are experienced scientists within your department or elsewhere who can give you a broader perspective on science and scientific politics. It is especially important to do this if your department has not assigned you an official mentor.

◆   Establish a set of confidants. These are people with whom you can openly share information about politically sensitive issues. Choose them carefully. You may be more comfortable limiting your confidants to one-on-one relationships. Or you may find a group that puts you in close touch with colleagues whose situations are similar to yours.

◆ Meet regularly with your formal mentors. Keep them apprised of your progress. Do not avoid them if things are going badly. Enlist their help.

◆ Keep meetings professional. Respect your mentors' time constraints. Be prepared and specific about what you ask for.

How to Be Mentored Well

Here are some qualities to cultivate in yourself as you seek to be mentored:

◆ *Foresight:* Start early to think about your future.

◆ *Proactivity:* Don't expect to be taken care of. You could easily be overlooked in the competitive world of science.

◆ *Probing:* Ask tough questions. Find out about the experiences of others with this potential mentor.

◆ *Respect:* Be polite. Make and keep appointments. Stay focused. Don't overstay your welcome.

◆ *Gratitude:* Everyone likes to be thanked.

◆ *Reciprocation:* Repay your mentor indirectly by helping others.

◆ *Humility:* Be willing to accept critical feedback so that you are open to learning new ways of thinking about and doing science.

When the Relationship Is Not Working Out

What you view as a problem may simply be a matter of personal style or a different understanding of the mentor's role. Have a conversation with your mentor about getting what you need. If that does not help solve the problem, you may need to think about finding other mentors. Consider finding another mentor if yours is clearly and consistently uninterested in you, undervalues your abilities, or displays any other signs of undermining the relationship. Consider finding another mentor if yours behaves inappropriately by violating workplace rules or fails to fulfill essential responsibilities to you—for example, by not sending letters of reference or by not reviewing your work. You may need to appeal to whatever conflict-resolution mechanism exists at your university. Start with the human resources office for guidance on how to proceed.

Adding new mentors may be helpful. However, be very careful about severing a mentoring relationship. Even if the relationship is not going well, you do not want to offend someone unnecessarily. If the relationship is official, ending it will require explicit action and most probably generate bad feelings. If the relationship is informal, and you can just allow it to peter out, do so. If your mentor wants to terminate the relationship, accept the decision with good grace. It will be better for both of you.

GENDER AND CULTURE ISSUES

Scientific labs are close quarters that ideally will create equally tight and fruitful working relationships. However, these working environments can also create friction and conflict. In addition, many labs include people from many different cultures and backgrounds, which can contribute to difficulties in communicating and to misunderstanding. For this reason, everyone in the lab has to work especially hard to show respect to other lab members. As the principal investigator you need to set the example by facilitating positive and cooperative relationships.

Teach your students and postdocs appropriate social behavior by

◆   Respecting other people and not offending them with jokes, pictures, or music that show disrespect for who they are or where they come from.

◆   Treating everyone fairly, and keeping the main focus on science.

◆   Respecting different sensitivities by tailoring your way of criticizing students to their personal style (e.g., some will be devastated by words that others take as simply a push in the right direction).

◆   Demonstrating your willingness to communicate with and to understand each student, regardless of their background and culture.

◆   Ensuring that all lab members feel physically safe while working in the lab.

As a principal investigator, you will also need to be aware of issues that are particularly relevant to certain segments of the population, such as women and minority and disabled students. Some of these issues are mentioned below.

Gender and Minority Issues

Role models and networking. African Americans, Hispanics, and American Indians are underrepresented in the science and engineering labor force. And in some fields of research, females are underrepresented either as students or at the faculty level. Be aware of minority support groups on your campus and of potentially helpful role models for minority students and postdocs. Similarly, women students and postdocs may not have access to the same networking opportunities as their male counterparts and may need your help in seeking these out. If you are a woman or a minority scientist, and you are making good progress on a career in science, younger women or minority students may want to know how you do it. If you have had failures, or are making compromises, they may want to know that too. You may want to share your experiences, positive or negative, with the next generation.

Discrimination and harassment. Be sure you are familiar with your institution's policies pertaining to discrimination and harassment. This knowledge will help you deal with the situation if you are approached by someone who believes to have been discriminated against, if you are accused of harassment or discrimination, or

if you become romantically involved with a colleague or someone you supervise. Understanding the nature of discrimination will help you avoid making unlawful mistakes and help you spot mistakes made by others. Be sure you know what offices in your university deal with harassment and discrimination complaints and offer training about university policies and procedures.

Sharing the load. If you are a successful woman or minority scientist, you may be called upon too often to serve on committees as the representative of your gender or group. Do what you can, but be selective and don't let committee work get in the way of your research. Have an answer ready so that when you are called to serve in some way that you feel taxes your time too much you can politely explain you have a lot on your plate at the moment. Alternatively, you can make it a policy to always ask for a day to think about a request for your time.

Family responsibilities. In many cases, women have the primary responsibility for the care of young children and aging parents. As a principal investigator, you should try to accommodate family obligations of all those in your lab who have such responsibilities (e.g., avoid scheduling mandatory meetings before or after the hours when child care is typically available). You may also consider what you can do more generally to be an advocate for family-friendly policies at your institution. If you are shouldering pressures of family responsibilities, find out whether your institution has policies or programs you can take advantage of to help alleviate those pressures (such as tenure clock extensions, part-time appointments, parental leave, and flexible work hours).

Teaching How to Mentor

Jo Handelsman, Christine Pfund, Sarah Miller Lauffer, and Christine Maidl Pribbenow of the Wisconsin Program for Scientific Teaching have developed a mentoring seminar to teach scientists how to be better mentors. Guided by a "facilitator" the seminar takes a group of mentors through different scenarios and situations that serve as teaching tools. It consists of eight sessions that provide an intellectual framework for mentoring, present various mentoring methods to experiment with, and describe dilemmas that participants solve through discussions with their peers. The manual for the seminar, entitled *Entering Mentoring: A Seminar to Train a New Generation of Scientists,* may be obtained from *http://www.hhmi.org/grants/pdf/labmgmt/ entering_mentoring.pdf.*

For more information about the Wisconsin Program for Scientific Teaching, visit *http://scientificteaching.wisc.edu.*

Cultural Differences

As a scientist, you are very likely to find yourself the mentor of students from other countries, or from minority groups within the United States. Language and cultural differences may make the mentoring relationship more challenging. For example, people from some cultures may convey information only in indirect ways, or they may be reluctant to argue with an authority figure. As a mentor, it is important to be aware of cultural differences when dealing with issues in the lab, and you should make an effort to learn about these differences. In addition, most campuses have resources to help foreign students become acculturated; encourage the people in your lab to get whatever aid they may need.

RESOURCES

American Association for the Advancement of Science. ScienceCareers.org has many articles on mentoring, *http://sciencecareers.sciencemag.org.*

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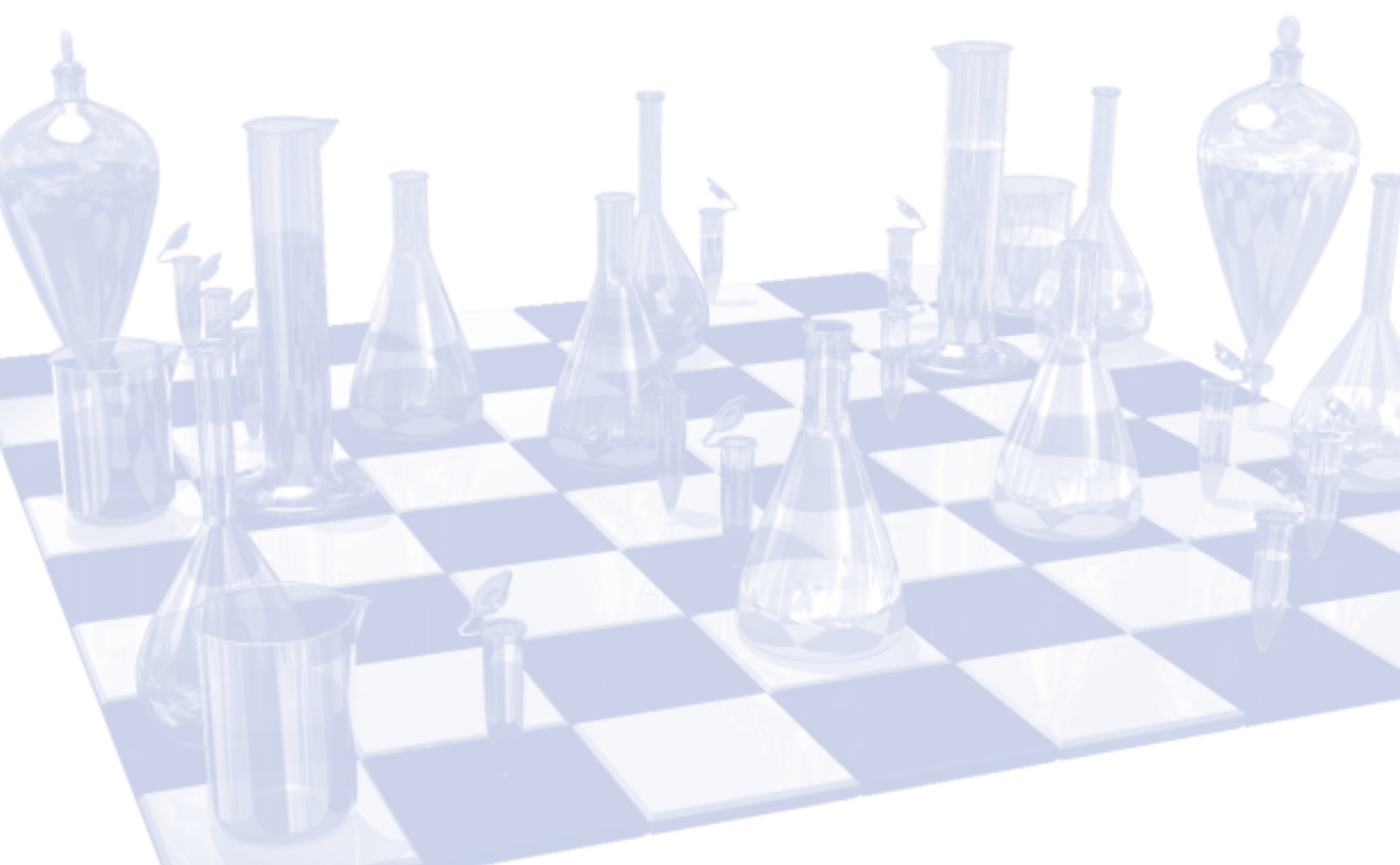
Chapter 6

TIME MANAGEMENT

From a practical perspective, one of the most daunting challenges for beginning investigators is learning how to cram an impossible load of new obligations into a 24-hour day. Finding ways to manage the conflicting demands on your time can be key to developing a successful career and a rewarding personal life. This chapter discusses planning strategies that are critical for successful time management, such as defining long- and short-term goals and setting priorities. Tips for day-to-day time management are also presented. The chapter also offers guidance on managing committee service commitments, balancing research and teaching, and juggling the demands of home and work. In addition, it covers issues specific to physician-scientists.

STRATEGIES FOR PLANNING YOUR ACTIVITIES

Defining Goals

Planning is a process that begins with a goal. Once you have set a goal, you can identify the necessary steps to move toward it. Goals come in descending sizes, each of which informs the next: long-term goals (years), intermediate-term goals (months), and short-term goals (weeks and days).

Long-term goals are likely to be a combination of tangibles (e.g., faculty promotions) and intangibles (e.g., a satisfying personal life) that may change over time, making goal setting an ongoing process that you should revisit periodically. In defining your long-term goals, you are also defining yourself—who you want to be and how you want to be perceived.

Intermediate-term goals, such as publishing a paper, are often composed of many short-term objectives, such as preparing figures for a paper. Short-term goals are the ones written on your weekly and monthly calendars—the small, concrete, finite tasks that can swallow your time.

Getting from Here to There

Take the time to craft a formal plan, beginning with your long-term goals. Then set interim goals along the way that are realistic indicators of progress. By setting achievable goals, you avoid having too much to do and not knowing where to begin. Accomplishing just one goal can serve as a powerful motivator to tackle the next goal.

> *The key is to identify what matters to you in terms of interests and values and then to apportion your activities throughout the day and week to address all of them.*
>
> —Richard Reis, Stanford University

Write down all your goals, with each achievement tied to a specific time frame. Putting your ideas into words can help refine your thinking and provide a concrete checklist to keep you on target. Every so often, take a look at your plans, reflect on them, and revise them as appropriate to changing circumstances. Priorities shift; be prepared to reevaluate yours but also to defend them.

Long-term goals. These goals can be achieved in three to five years. Before jotting down your long-term plans, first ask yourself where you want to be after this stage in your career. For example, if you are a postdoc, do you plan on an academic or applied position? At what type of institution—a research-intensive institution, teaching college, or other? Now ask yourself, "What will I need to accomplish to make myself competitive for that job?" If you are an assistant professor, you probably want to work toward tenure. Knowing when you'll be up for tenure, ask yourself, "What will I need to do by then—how many papers, invited seminars, professional meetings, and other accomplishments?"

Intermediate-term goals. These goals can be achieved in six months to one year. For example, as a postdoc you should be thinking about the experiments needed to complete your next paper or to put together a poster. Completing publishable chunks is an essential intermediate-term goal for faculty. Other such goals are obtaining preliminary results for a grant, putting together a new course, and organizing a meeting.

Short-term goals. These goals can be achieved in one week to one month. They include preparing figures for the paper you're writing, completing an experiment, preparing reagents for the next set of experiments, or writing letters and making phone calls to secure a seminar invitation. If you find it hard to get organized, make a daily or weekly to-do list and check tasks off as you complete them.

Making Choices

Saying no, saying yes. One of the simplest things you can do to streamline your life is, for many people, also one of the hardest: Learn to say no. Remember, you can't do everything, please everyone, be available to everyone, and at the same time be an ideal teacher and scholar. There are certain tasks you must say no to and others for which it's fine to deliver a less than stellar performance. Making such choices will allow you to focus on doing an outstanding job in what's truly important to you. Establishing these priorities depends on the intermediate- and long-term goals you have set for yourself.

Saying yes judiciously will make it easier for you to say no to things you do not want to do. Because you must accept some administrative assignments, try to make them work for you. Explore the options, and sign up early for duties that either interest you or will work to your advantage professionally. This will then allow you to turn down administrative duties that have less value to you.

Maximizing returns. Given the ever-increasing demands on your time, it is impossible to do everything perfectly. Decide which projects need to be completed to near perfection (e.g., your grant application) and which do not (e.g., a draft of a manuscript you are reviewing for a collaborator).

Disconnecting. Part of saying no is also not being available on demand. Today's technological "conveniences" are often needless interruptions to concentration. Any sound strategy for time management involves learning to disconnect—be the master of those tools rather than their servant.

MANAGING YOUR TIME DAY TO DAY

Many people find long-term goals easy to set—for example, "I want to be a full professor by the age of X." More difficult is the daily multitasking—managing the flood of small chores that can threaten to drown even the most organized professional. This section covers how to make the most of the time you have.

Finding Some Extra Time

To be able to focus and think creatively, you need blocks of uninterrupted time. Here are some tips to help you do this:

◆ Get your e-mail under control. If you're lucky enough to have administrative help, have an assistant screen messages and flag time-sensitive ones for you. You can also print e-mail messages that require a personal reply and hand write responses during short breaks in your day. Then have your assistant type and send them later. If you don't have an assistant, set aside specific times of the day for reading and responding to e-mails or read your e-mails at home in the evening.

◆ Buy an answering machine or voice-mail service.

◆ Invest in a family cell phone plan to make sure you're available for family communication and emergencies when you have silenced your office phone.

◆ Close your office door or come in early. A sign on your door that reads "Knock if important" lets your students and colleagues know you are in and working, but don't want to be disturbed. Early hours might buy you precious focused time away from clamoring students and colleagues.

◆ Close your lab door. Securing uninterrupted time in the lab is of paramount importance to your career.

◆ Make, and keep, appointments with yourself. Find a quiet hideaway and use it on a scheduled basis. This practice trains people to expect you to be inaccessible at predictable times.

Rotating Your Tasks

If you tend to have difficulty focusing on one task for long periods, you can turn this potential weakness into a strength through multitasking. Make sure that you always have several things to work on (e.g., the introduction to a grant, a paper to review, or a recommendation letter to write), perhaps three or four, and cycle through them with increasing lengths of time. Make sure they are clearly arranged on your desk so that you don't waste time figuring out what you should do next.

Seven (Not So Obvious) Keys to Working and Living Right

1. Learn how to say yes as well as how to say no. It's easier to say no to unwanted tasks if you have already committed to something you do want to do.

2. Establish your absence as well as your presence. Set a schedule for being physically elsewhere and unavailable, and stick to it.

3. Do a little bit of everything as well as all of one thing. Master the art of multitasking.

4. Determine your tasks as well as your priorities. There are many activities, small and large, that lead to your goal.

5. Work until your time is up as well as until your task is done. Approach every task with the goal of making progress during a specific amount of time, then move on to the next task to maintain forward momentum.

6. Bring some of your home to work as well as some of your work to home. You live in both worlds; look for ways to bring them together (e.g., if you have a long commute, leave home early to beat the traffic and save breakfast and the newspaper for your office).

7. Seek to integrate your professional and personal activities where appropriate as well as to separate work and play where appropriate; doing so can maximize your effectiveness and satisfaction in both areas.

Source: Richard M. Reis, Stanford University.

Setting Priorities

On the basis of your goals, decide what you need to do and when, and follow the classic KISS rule: Keep It Simple, Stupid. A grid that allows you to rank short-term claims on your attention according to urgency and importance can be a useful tool (see figure 6.1). Try to control the not urgent/not important quadrant. You get relatively little value for the time spent doing tasks in this quadrant. The urgent/important quadrant puts you in crisis mode, where few people operate best. For maximum efficiency, you should be spending most of your time in the upper right-hand quadrant on tasks that are important but not urgent.

If it's important but not urgent, remember your priorities and schedules:

◆ Plan ahead and know your deadlines.

◆ Set aside blocks of time for specific tasks.

◆ Break large tasks into smaller tasks.

◆ Delegate tasks.

◆ Complete tasks on time.

Making the Most of the Time You Have

It's important to find ways to make efficient and productive use of your time. Be aware that for some activities, it may not be immediately apparent that your time spent is worthwhile. For example, attending seminars in your department can actually be a productive and efficient use of your time. Not only will you learn new information, but if you ask questions, you will also boost your visibility.

Efficiency. Successful people tend to be efficient. They have evolved practices to create blocks of uninterrupted time for "brain work." Here are some tips to help you make the best use of those parts of the day you control:

◆ Create an environment conducive to productivity. Make a place for everything, and put everything in its place; clutter is inefficient. Find or make a quiet space (or time) to work.

◆ Know your biological clock, and protect your most productive hours for your writing and designing experiments and other critical tasks.

Figure 6.1. Time management grid

	Not Important	Important
Not Urgent	• Most e-mail • Weekend plans of lab members • The Super Bowl pool	• Ongoing experiments • Preparing for a committee meeting • Next month's grant deadline
Urgent	• "You've got mail" alert • Ringing telephone • Inquiring colleague	• A lab fire • Tomorrow's grant deadline

Source: Sandra L. Schmid, The Scripps Research Institute, adapted from Stephen R. Covey's time management matrix in *The Seven Habits of Highly Effective People: Powerful Lessons in Personal Change*.

◆ During your protected work hours, focus and don't allow interruptions.

◆ Set time limits. Give yourself predetermined amounts of time to complete tasks (e.g., two hours to review a paper).

◆ Eliminate unnecessary tasks.

◆ Avoid procrastination. Start tasks early—at least in outline. If you have a grant due, write your goals early enough to let your lab staff start gathering relevant data without last-minute panic. If a critical reagent requires a long lead time to produce, start it early enough to make sure it's ready when you need it.

◆ Structure and supervise meetings.

◆ Delegate work.

◆ Make a quick phone call instead of having an often less efficient back and forth e-mail conversation.

◆ Get a high-speed Internet connection at home.

> *Having a high-speed Internet connection at home has revolutionized our lives. I can be home at 5:00, put the kids to bed, get on the PC, and do everything from home. It has really improved our parenting and family abilities with more efficient time management.*
>
> —Milton Datta, Emory University School of Medicine

Fitting it all in. Successful people also learn to use small units of time, capitalizing on free minutes here and there (in many professions, people bill their time in increments of 15 minutes or less). Returning phone calls, drafting memos, and reviewing your weekly schedule are just a few ways in which you can put a few minutes to work for you throughout the day. The trick is to be prepared when those moments arise by having messages or e-mail, students' homework, a notepad, and perhaps a cell phone with you. Some tasks, such as reviewing papers and reading science magazines, adapt well to commuting time if you don't drive.

> *Be prepared to take advantage of small chunks of time. In 5 to 10 minutes, you can make a quick phone call, handle an e-mail requiring a personal response, or fill out a form.*
>
> —Sandra Schmid, The Scripps Research Institute

Improving Your Lab Staff's Time Management Skills

Here are some tips for helping your staff work more efficiently:

◆   Establish clear goals and expectations early, starting with simple tasks your staff can handle. Make sure they understand the tasks. Reward and correct them as appropriate, expand the tasks, then repeat the process.

◆   Help them seek advice without taking up unnecessary time. Teach them how to describe projects, issues, and problems accurately and efficiently.

◆   Develop an agenda for every meeting—and stick to it. Start meetings with a clear description of the purpose of the meeting and when it will end.

◆   After meetings, send a "Dear gang" follow-up letter containing a summary and to-do list. Use these informal minutes to start the next meeting and gauge progress. (Meeting minutes are also useful for patent protections in establishing proof of an idea, attribution, and date.)

Once the members of your lab learn the importance of time management, you can also delegate to a key staff person the task of summarizing meetings and assigning follow-up actions.

> *Investment of time to train others does pay off in time efficiencies.*
>
> —Richard Reis, Stanford University
>
> *When your lab members report to you on a project, request that they first provide some context and then organize what they tell you in concise bullet points of information: "I'm going to tell you about this morning's experiment. This was the result. This is what I think it means. This is what I plan to do tomorrow." With this strategy, a five-minute interaction can get you immediately connected to what the person is doing.*
>
> —Todd Golub, HHMI and Dana-Farber Cancer Institute

SPECIAL ISSUES

Managing Committee Service Commitments

Committee duties can connect you with interesting people—in your department, your institution, and beyond. They can also help bring your research to the attention of your colleagues—a genuine plus for a beginning faculty member.

But how can you avoid spreading yourself thin with committee service obligations? Be proactive and seek out committee service that suits your interests and schedule so you can turn down other requests with the legitimate excuse of previous committee commitments. Women and underrepresented minorities need to be particularly good at saying no because they're frequently asked to serve on committees.

> *Try to volunteer for something that you care about or that would benefit you. For example, the graduate admissions committee is often of great interest to a starting assistant professor. Then use these commitments as a reason to decline other opportunities for committee work that come along. So the next time someone comes and tells you about this great committee that they would like you to sit on, say, "I would really love to do that, but it turns out I just agreed to do this huge graduate admissions committee job. It's going to be very time-consuming and it's so important." And then they will nod understandingly and, hopefully, walk out the door and not ask you again.*
>
> —Thomas Cech, HHMI

Research and Teaching

If you're in a department that values good teaching and you're thinking about tenure, if you want your course material to be up to date and engaging, or if you are responsible for difficult material you don't fully understand, you may find yourself dedicating a large portion of your time to teaching at the expense of everything else. For the sake of your research career, you must learn to control your class-related hours. Chapter 13 "Teaching and Course Design," page 211, offers some strategies on how to do this.

Even though it is difficult, you have to set limits for nonresearch tasks and stick to them. When time is up for one task, move on to the next item in your daily planner. This way, you start each day anew without carrying forward serious work deficits that accumulate throughout the week. As a guideline, one senior scientist advises that regardless of how much office work you have, as a beginning principal investigator, you should be spending the equivalent of at least two full days in the laboratory every week.

Special Issues for Physician-Scientists

The Triple Load of the Physician-Scientist: Lab, Class, and Clinic

Although physician-scientists may have some teaching duties, these duties usually aren't extensive. The larger challenge for a physician who is running a research lab is balancing lab and clinical time. An even split between the lab and clinic is increasingly rare; it can be as much as 80 percent lab and 20 percent clinic, but it varies considerably from person to person and by the nature of the work. Here are some tips for straddling the lab and the clinic.

In the lab:

◆ Consider investing in a lab manager. These individuals usually have an advanced degree or a lot of experience and are thus more expensive, but a good lab manager will help keep the lab on track while you are on clinical duties.

◆ Establish a system where you can review the lab members' notebooks and data even if they are not there (e.g., if clinical duties keep you from being in the lab until late in the evening).

◆ Explain to your lab members that you will not be around much when you are on clinical duty. Try to schedule times when you can meet with your students and postdocs to keep yourself apprised of their progress.

◆ Focus your research program on what you're uniquely qualified to do.

In the clinic:

◆ Tell patients how you want to be contacted.

◆ If you have access to support staff (and many junior faculty do not), use them effectively. Educate nurses or "physician extenders" to do as much of the preparation as possible before your appointments, as well as the follow-up.

◆ Learn to tell patients when you have to stop.

◆ Make patients and colleagues aware of your dual roles.

Remember, in the lab, in the clinic, and at home—the most important thing you need to learn is to be flexible with your priorities.

Home and Work: Can You Have It All?

This question applies to many professionals in high-pressure careers, including male and female scientists pursuing academic career tracks.

Family communication. It helps to start with a supportive partner and family. Have clear discussions about career and personal goals—yours and those of your family—early on. To avoid the resentments of unspoken and unmet expectations, be as explicit as possible about your aspirations with those who are important to you. Shared goals for work and family make compromises easier.

In addition to sharing your long-term goals, keep your partner and family aware of your short-term plans and projects. Letting your partner know in advance about an impending grant deadline can buy some understanding. Here are some ways to keep your family informed of your schedule and you involved with your family:

◆   Post a calendar at home with your travel dates and big deadlines.

◆   Schedule activities with your family and keep those commitments (e.g., Friday date night).

◆   Turn business travel into a vacation. Have your partner join you after a scientific meeting and take a few days together to unwind.

◆   Involve your partner in your work if he or she is interested. Having partners read over a grant application allows them to contribute, and you benefit from a fresh set of eyes to find typos.

> *One problem I see with clinician-scientists is that the clinic creeps into every day's work, with phone calls, prescription renewals, acute medical needs, lab follow-up, and management of paperwork. In my experience, it has been valuable for junior faculty to define their availability to the infinite demands of patient care. For example, it may help to limit clinic duties to one full day per week rather than two half days or to choose to do clinical work that can be done in chunks (such as inpatient rounding) and does not require follow-up.*
>
> —Ann Brown, Duke University School of Medicine

Balancing work and children. Unquestionably, children complicate the equation, but they can also provide the sanity, personal satisfaction, and motivation to make you a more focused and efficient scientist. Few professionals are willing to forgo having children in order to facilitate career advancement, nor should they. High-quality day care, domestic services, and shopping conveniences make raising a family and having a challenging career sustainable and enriching. Indeed, being the boss (e.g., running a lab) can give you the flexibility and the financial resources to make the choices and adjustments necessary to maintain a balanced lifestyle. Here are some tips for balancing work and family life:

◆   Take advantage of options for assistance in cooking, cleaning, and other domestic chores, and don't waste energy feeling guilty. When your budget allows (and in the early years, it may not), buy yourself time: Hire help with housecleaning—even if you can afford only semimonthly scouring of the bathrooms and kitchen. Until then, a messy (but reasonably clean) house won't hurt you or the kids. Later, a nanny or housekeeper (who also does laundry) is worth the investment.

◆ Eat out with your family once a week or once in a while, even if it's fast food. This is an easy family-focused activity you can enjoy together outside the house.

◆ Pick up carryout meals to eat at home. This break from cooking will stretch the dinner table time you have to share information about everyone's day and allow you to play with younger children and put them to bed.

◆ Teach your children how to help out with age-appropriate chores (e.g., putting their clothes in a hamper, putting away clean laundry, setting the table).

◆ When you do cook, keep meals simple and make large quantities that can be frozen in meal-size portions for use throughout the week.

◆ If you and your partner both work outside the house, make the best child-care arrangements you can. If you're away from your child all day, it's especially important to carve out inviolable family time on evenings or weekends.

Is it possible for ambitious scientists to have it all? For those who learn to balance competing demands, the answer is a qualified yes. The key—admittedly easier said than done—is to identify what matters most to you and then to apportion your activities throughout the day and week to address them all. The important thing is to set your priorities, learn to compromise, and be flexible.

> ❝
>
> *I don't sell cookies or gift wrap for my kids' school; I write checks. I don't volunteer in their classrooms; I go on one field trip a year, which means a lot to my kids. My family takes a two-week summer vacation, a trip at spring break, and long weekends away.*
>
> —Sandra Schmid, The Scripps Research Institute
>
> ❞

RESOURCES

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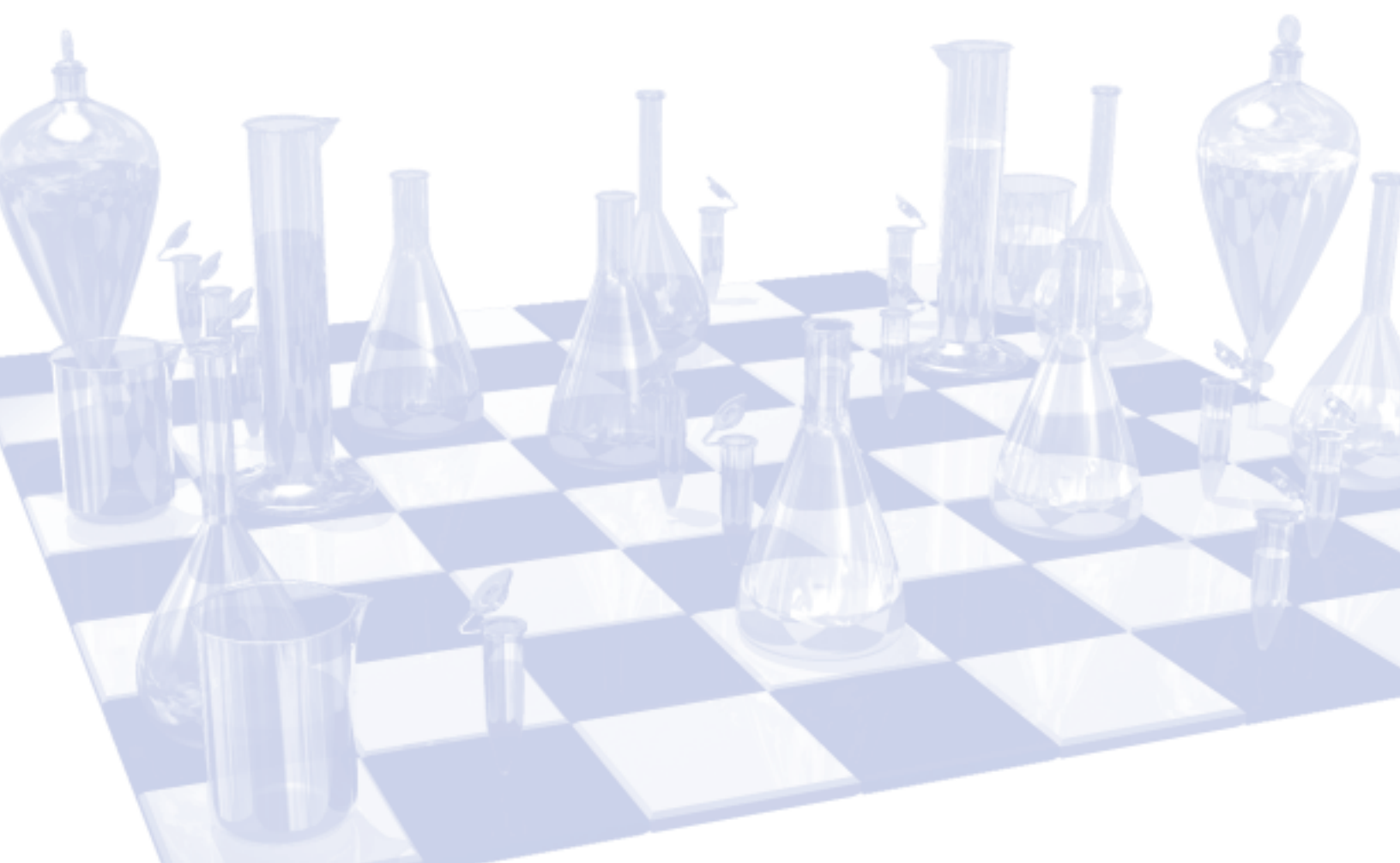
Chapter 7

PROJECT MANAGEMENT

To increase the output of your laboratory, you can either increase resources—by getting another grant and recruiting more people to work with you—or make better use of what you already have. One tool for achieving the latter is project management. Put simply, project management means allocating, using, and tracking resources to achieve a goal in a desired time frame. In a scientific setting, goals may include publishing a paper, obtaining a research grant, completing a set of experiments, or even achieving tenure. While keeping creativity intact, project management can help reduce wasted effort, track progress (or lack of it), and respond quickly to deviations from important aims. This chapter highlights some of the techniques of project management and how you can use them. The appendix at the end of the chapter shows a real-life example of project management applied to a project to determine the role of a gene in prostate cancer.

> *Project management helps you efficiently use your research funds, personnel, and time to publish research papers, obtain funding, and be promoted.*
>
> —Milton Datta, Emory University School of Medicine

WHAT IS PROJECT MANAGEMENT?

Project management is a series of flexible and iterative steps through which you identify where you want to go and a reasonable way to get there, with specifics of who will do what and when. The steps of project management are similar to the components of a grant proposal (see chapter 9, "Getting Funded"). With a grant proposal, the probability of success is proportional to the thought that has gone into each part of the proposal. The reviewers as well as the funding agency staff want to see that you have thought things through. The same process also applies to other aspects of running your laboratory and planning your career.

> " *A detailed, well-designed project plan is one of the sharpest tools available for convincing a funder, such as NSF or NIH, to give you the resources you require.*
>
> —Stanley Portny, Stanley E. Portny and Associates
> "

Deciding on a Project

You may have an endless number of ideas for projects, but your resources (e.g., research funds, number of students and postdocs, time, and so on) are limited. The first thing you will have to do is decide which projects to pursue within the limits of your resources and considering your laboratory's mission (see chapter 3, "Laboratory Leadership in Science").

For, example, you may want to obtain a second R01 grant because it will allow you to pursue another line of research and increase your chances of obtaining tenure. The grant deadline is in nine months. You should ask yourself the following:

◆ What experiments do I need to conduct to write a research paper and submit it for publication before the grant deadline?

◆ Do I have enough time to obtain the necessary data?

◆ Which students and postdocs could generate these data?

Once you have defined your overall objectives, how to get there, and from whom you need buy-in and participation, you can start the process of planning your project, working backwards from your stated objective:

My project is to get an R01 funded within one and a half years.
I will need to

◆ *Obtain final data for the grant proposal (12 months)*

◆ *Submit the grant with preliminary data (9 months)*

◆ *Submit a paper for publication (6 months)*

◆ *Integrate data and start writing a manuscript (5 months)*

◆ *Complete the initial set of experiments (1 to 5 months)*

Project management consists of planning each part of your project using the tools outlined in the sections below. One of the most important benefits of project management is that it helps you accurately anticipate how much time a project will take and what resources you will need. Even if some back-of-the-envelope thinking convinces you that a project is worth pursuing and that you can generate an initial set of publishable results for your grant in five months, you will need to plan each

step more carefully to answer the following questions:

◆ How long will the project really take?

◆ Do we really have the people to do this?

◆ Do we really have the funds to do it?

◆ Can we get it done in time?

GETTING STARTED

The Statement of Work

The statement of work is a written document that clearly explains what the project is. It should include the following sections:

Purpose. This section should include

◆ *Background:* Why was the project initiated and by whom, what happens if it's not done, and what else relates to it?

◆ *Scope of work:* What will you do?—a brief statement describing the major work to be performed.

Question: Don't the strict definitions you impose when you set up a project management plan limit scientific creativity?

Answer: Not at all. All projects, including highly innovative ones, rely on defined resources. Regardless of the scientific goals of a project, project management helps you determine whether your ideas can be implemented with the resources at hand and how best to approach these ideas. If you realize ahead of time that you don't have the resources you need, you'll know you need to get them.

Question: Does project management discourage us from trying high-risk projects?

Answer: Scientists must work within the limits of their resources. This does not mean high-risk projects should not be done; it just means that one should know the risks involved before starting the project. Project management helps define what the risks will be; for example, you may use up your start-up funds before you get an NIH grant or you may produce one paper, rather than three, in one year. Once you know the risks involved, you can plan for them. Project management can also help you conserve some of your resources to use for high-risk projects. The more information you have at the outset of a project, the better you will be at allocating resources. The better you are at allocating resources for the work that has to get done (e.g., the experiments proposed in your funded grant), the more likely you will be able to save some funds for more speculative projects.

Question: Given the uncertainties in science, is project management feasible?

Answer: Project management isn't meant to be rigid or blindly restrictive. Indeed, by reexamining goals and circumstances in a systemized way, project management encourages you to reconsider which path is best many times during the course of a given project.

◆   *Strategy:* How will you perform the work, who will do it, and what funds are available for the work?

Objectives. Objectives are the end results achieved by the project. Each objective should include

◆   *Statement:* A description of the desired outcome when the project is completed.

◆   *Measures:* Indicators to assess how well you have achieved the desired outcome.

◆   *Specifications:* Target values of the measures that define successful results.

Constraints. These are the restrictions on the project, which fall into two categories:

◆   *Limitations:* Constraints set by others (such as limited start-up funds for your laboratory, or teaching responsibilities that will limit your research time).

◆   *Needs:* Constraints set by the project team (such as wanting to complete a project three weeks early because one of the key people will be leaving the lab).

Assumptions. These are the unknowns you posit in developing the plan—statements about uncertain information you will take as fact as you conceive, plan, and perform the project (e.g., you may assume that your clinical or teaching loads will not increase in the next year or that no one will leave the project before a certain milestone is reached).

Be aware that as your project progresses, your goals may change. Build in periodic reviews of results against objectives and revise the objectives if necessary. No matter how much you've invested in a project, it's never too late to redirect or stop work altogether if you discover, for example, that another route is more promising than the main avenue of research, or a key premise was off base, or that someone publishes the work before you do.

The appendix at the end of this chapter shows a real-life example of a statement of work.

Defining the Audience

Any of your audiences—the people and groups that have an interest in your project, are affected by it, or are needed to support it—can sink the entire enterprise if their needs are not considered. Early on, you should make a list of the project's audiences, both within your institution and outside it. Although you can do this in your head, a written list serves as a reminder throughout the project to touch base with these stakeholders as you proceed. A project can succeed only if everyone involved does his or her part.

Divide your audience list into three categories:

◆   *Drivers:* People who tell you what to do, defining to some degree what your project will produce and what constitutes success. As a principle investigator, you are the main driver for your research. Additional drivers might include competitors and collaborators in your field, the editors of scientific journals (if they are advising you on what experiments should be done in order to get a manuscript published), and the study section reviewers of the research grants (if their feedback is shaping the course of your research project). If possible, keep these people abreast of how the project is going or consult with them before changing direction or branching out in a different area. For example, if an editor at *Nature* has requested specific experiments in a revised manuscript but you decide to do different ones that you think are more appropriate or easier to do given the expertise in your lab, you can contact the editor to make sure that the proposed experiments will satisfy his or her requirements.

◆   *Supporters:* People who will perform the work or make the work possible (e.g., the students and postdocs in your lab as well as the program director for the organization that is funding the project). Make sure that these people are motivated to do the work and understand how what they are doing relates to achieving the overall scientific goal. (See chapter 3, "Laboratory Leadership in Science.")

◆   *Observers:* People who have an interest in your project but are neither drivers nor supporters. They are interested in what you're doing, but they're not telling you what to do or how to do it (e.g., other scientists working in your field, mentors, and potential supporters). It can be helpful to your career to let as many scientists as possible know what you have accomplished. This can be done by giving presentations at meetings and conferences, by asking colleagues to review a manuscript that you are preparing to submit for publication, or by sending scientists in your field copies of a paper you have published. Keep in mind that people who are familiar with your work, but who are not direct collaborators, will have to submit letters for your tenure. These people might also invite you to give talks or suggest that you participate in study sections or become part of a meeting planning team.

As you work on the project, revise the list as necessary. Categorizing audiences is less difficult than it may look, and you don't have to start from scratch for every activity. Many of the same people are likely to be on your audience list over time for different activities.

Defining Who Does What and When

The work breakdown structure (WBS) is an outline of all the work that will have to be performed for your project. To develop a WBS, start with broad work assignments, break them down into activities, and divide these into discrete steps (see the appendix for a real-life example). In the jargon of the project management field, an

activity is a task that must be performed for your project and an event is a milestone marking the completion of one or more activities. You will want to list on your timeline resources and the people that will carry out the activities, so that you can successfully complete some milestone event—for example, getting a paper accepted, a grant funded, or a difficult technique reduced to practice.

The WBS is one of the most important elements of project management as it will help you schedule the project and its parts, estimate resources, assign tasks and responsibilities, and control the project. (For more information about developing this kind of outline, see *http://www.4pm.com/articles/work_breakdown_structure.htm*).

When you develop a WBS, think in one- to two-week increments. You probably wouldn't want to include detailed plans for activities that take less time (e.g., experiments to be done each day). However, the level of detail you include in your WBS depends, in part, on who is doing the work. Most undergraduates will need more detail than an experienced postdoc or technician. It may be useful to teach your trainees to think in this time- and resource-aware way, perhaps by, early in their stay in your lab, having them write out detailed weekly plans or design flow charts for how they intend to work through a difficult technical issue at the bench.

To decide whether a particular part of the project is detailed enough, ask yourself these three questions. Based on the WBS can

◆ You determine a reasonable estimate of the resources (including people) required for this work?

◆ You determine a reasonable estimate of the time required to do this work?

◆ Anyone charged with one of these activities understand it well enough to do it to your satisfaction?

If the answer to any of these questions is "no," more detail is necessary.

In science, it's unlikely that you'll be able to make a detailed plan very far in advance. Much of the detailed planning will be done "on the fly" as the project proceeds. Try a rolling approach, in which you revise estimates in more detail as you progress through the project.

In addition to planning experiments, you can use the WBS to set up the lab and divide big tasks into smaller ones—for example, ordering equipment; hiring staff; and dealing with institutional review boards (IRBs), radiation safety, and other issues.

Question: Is project management a top-down or a mutual process?

Answer: It must be mutual. For the best possible outcome, you need both staff insights and "buy-in." Project management does not say, "Forget thinking and just do what I say." It's a process for identifying what to think about, not how to think about it.

Question: If I have experiments A, B, C, and D, is it reasonable to do detailed planning only for A first and deal with the others later?

Answer: That may be reasonable, but what if B isn't entirely dependent on A, and you could have done some work for B or any of the other experiments without waiting until A was done? Project management tools and software can help you see where timelines may overlap, so that you can use your time most productively.

TRACKING THE WORK AND THE RESOURCES

Complex projects require a series of activities, some of which will have to be performed in sequence and others in parallel. Project schedules outline the order in which activities are to be performed and estimates of how long each will take. In addition, for each step of the schedule, you will need to assign the necessary resources, including people, funds, equipment, supplies, facilities, and information. To schedule your activities and resources, you will need to follow these steps:

1. Identify activities and events (from the WBS).
2. Identify constraints (from the statement of work).
3. Determine the durations of different activities and, if more than one person will be involved, who will be doing them.
4. Decide on the order of performance.
5. Develop an initial schedule.
6. Revise your schedule as necessary.

Tools for Developing Schedules

You have probably seen some of the tools for developing schedules, timelines, flow charts, and so on, before. Here are some popular ones:

◆ *Key events schedule:* A table showing events and target dates for reaching them (remember that events are milestones signaling the completion of one or more activities).

◆ *Activities plan:* A table showing activities and their planned start and end dates (see appendix, page 141).

◆ *Gantt chart:* A graph consisting of horizontal bars that depict the start date and duration for each activity (see appendix, page 142).

◆ *PERT chart:* A diagram in which activities are represented by lines and events on the nodes (typically depicted as circles or bubbles).

The key events schedule and the activities plan display dates better; the Gantt and PERT charts give a better overview of how long activities take and where they coincide. Regardless of which format you use, take the time to develop a schedule you have a reasonable chance of meeting. Think realistically and estimate how long each step will take, how many uninterrupted hours you have available during the day, and how other demands on your time will affect what you or your lab can get done.

To determine how long a very complex process may take, think about similar things you've done before. Flip through your notebook or calendar and try to remember—how many hours did it really take you to write, edit, get feedback on, make figures for, revise, revise again, and submit that last paper or grant? Try to be conservative in your estimates. When it comes to planning benchwork, an accurate assessment of the skills, experience, and limitations of your staff will help

you match the right people to each task. Stretching is good, but failing because of overreaching is not. If your team lacks the expertise required for completing a specific goal you may need to find a suitable and willing collaborator. Collectively these scheduling tools will

◆ Provide ways of tracking the work.

◆ Identify the order of experiments, which will define how long it will take to get the job done.

◆ Show the relationship of experiments to each other (e.g., do they need to be done sequentially or can they be done in parallel?)

◆ Identify bottlenecks.

As the work progresses, make adjustments to your schedule or the resources needed. For example, the estimates of times can be replaced with actual times. In cases where there are delays in the schedule, additional resources may be needed to make up for time and the diagram may be modified to reflect the new situation.

Question: It sometimes takes longer than I think it will to complete new experiments. How do I plan accordingly?

Answer: The work breakdown structure will help you see where inherent difficulties in experiments or bottlenecks in the procedures are, and you can then add time and resources to address these. For example, you may pair an experienced postdoc with a new student who is responsible for a step in the protocol, or give a technician who has to establish a new technique in the lab time for several trials and revisions of the procedure.

Do I Have the Resources?

Once you have made an outline of the activities to do in a given timeframe and who will perform the work, you may want to more precisely determine how much of a given resource the project will use up—e.g., how many hours a postdoc will have to work each week to complete his or her activities (see appendix, page 142) or how much money will be spent. This will help you identify potential bottlenecks—even the best postdoc cannot work 37 hours a day!

PROJECT MANAGEMENT SOFTWARE

If you are keeping track of a simple project involving only one or two individuals, you can probably use a network diagram drawn on a board or in an electronic document. But as the number of projects and responsibilities you juggle grows, you may want to make use of one of the many software packages available. They can help you spot, for example, resource conflicts (such as one person assigned to three overlapping activities) and identify which activities can be delayed to accommodate that problem without jeopardizing the schedule. Good software helps you brainstorm the organization of activities on screen, create a WBS, link activities, develop a schedule, identify resources, maintain information on progress, and generate reports. When you make a change, the software reflects the impact of that change throughout the project.

Microsoft Project, a program that seamlessly integrates with Microsoft Office, is a popular choice. The software package lets you enter any number of tasks and schedule them. You can then view the data using multiple formats (e.g., Gantt charts or PERT diagrams). You can also enter cost for each resource and the software will automatically track the spending of the project. Other popular choices are the packages Act! (Symantec Corp.) and Now Up-to-Date (Qualcomm, Inc.). For information about others, see *http://www.project-management-software.org*. Like other software, project management programs come with bells and whistles you may never need or use. Remember that software is merely a tool to help you plan and organize your work. It should not become your work, bogging you down in complex manipulations or fancy graphs and charts that look impressive but don't improve on simpler presentations of the information.

After some short training on these software packages, it is straightforward to build new plans. Several fields, including construction and some areas of business management, make extensive use of this kind of software. You may be able to find undergraduates, especially in engineering or business schools, who would be eager to polish their skills (and get a line for their résumé) by doing the grunt work needed to move your established pencil-and-paper plans onto the computer.

Question: I've done some experiments so many times that I already know how long it will take and the resources I need. Should I add these experiments to my plan?

Answer: Not for your benefit, but you have to consider whether others need to know what you're doing—the sequence of steps as well as the materials and time required. If they do, a written work plan can also be a useful part of the record. Project management isn't just a planning tool, it's also a training and communication tool.

Question: Despite the best explanations, inexperienced students may focus only on their part of the work. Are there devices to help them get the big picture?

Answer: It's important that they do get the big picture, and project management may be part of the solution. Although it's true that project management encourages a focus on details, it also encourages you to consider the big picture. Think of a project's detailed plan as being like a metabolic map: If students can see how their work connects to a greater whole, they may be more motivated to think about their own small projects and to ask bigger questions about the lab's work and the broader field. Young students may be reluctant to admit what they don't know. By walking them through the field's complicated issues and ongoing controversies, you can convey to them that it's alright not to know and customary to ask others to explain things. Get them to talk about what they're doing, and paraphrase what they say, highlighting the places where their work intersects with other work in the lab, or ask them to write a statement of work for their part of the project, which requires knowing the background on the project as a whole.

CONTROLLING THE PROJECT

Effective project management demands that the components of a project be constantly monitored and revised with new information. The principle investigator typically plays this role in addition to the following tasks:

◆ Championing the project for the project audience (e.g., through seminars and informal updates to supporters).

◆ Clearing away obstacles for the project team (such as minimizing other responsibilities for the team members and providing a supportive and comfortable work environment).

◆ Providing resources, by way of funds, access to essential equipment, and technical skills.

◆ Communicating the project vision to keep the team motivated and focused.

◆ Communicating with the department chair, NIH, journal editors, and the external collaborators.

> "
>
> *The greatest chances for success are achieved when project information is used to align, guide, and motivate team members, and when these team members, in turn, use this information to guide their work.*
>
> —Stanley Portny and Jim Austin, "Project Management for Scientists," ScienceCareers.org, 2002
>
> "

Keeping Your Work on Track

It is hard to predict how the course of a project will run. Flexible planning is needed to help you deal with the unexpected and still keep your many projects moving. The following is a list to help you stay on track:

◆ As you would do in a good R01 or other grant application, consider different scenarios to identify what may not unfold as you anticipate, and identify the range of ramifications and how you would address them.

◆ Select aspects of your project that are most likely to slow things down (e.g., a graduate student who is not familiar with interpreting experimental results and thus may slow progress or a technician who does not aggressively follow up on orders from a slow vendor and thus may not receive needed reagents on time), and monitor them closely.

◆ Develop strategies to reduce the likelihood of deviations, as well as contingency plans for any that occur.

◆ Create indicators or defined results (such as a completed Western blot or a clearly interpretable experimental finding) that will help you evaluate the project against your stated objectives. The indicators should be clear and directly relate to your objectives. Poorly chosen indicators are worse than none at all and may cause you to abandon a project when in fact the objective may be sound.

◆ Monitor the project carefully and consistently to promptly identify detours from course.

◆ Implement contingency plans, and revise your master plan as necessary.

Question: How do I finish projects while allowing key people to leave when they're ready?

Answer: Project management can help you anticipate and plan for their departure. Identify who's most likely to leave and the places in the project where that's most likely to happen. When it does happen, stop and assess the impact on your project and determine steps you can take to minimize the effects.

As a scientist, you want your work to be worthwhile, even if it doesn't proceed the way you planned or produce the expected outcome. To get the most out of your investment of project resources, learn to work through the "what ifs" by positing multiple possible outcomes and timelines, and planning ways to deal with each one.

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APPENDIX: PROJECT MANAGEMENT— A REAL-LIFE EXAMPLE

The Statement of Work

Section 1: Purpose

Background. Theresa, a postdoc in the laboratory, wants to examine the possible role for alterations in the gene *Sumacan* in prostate cancer. She noted that *Sumacan*, which encodes a growth factor receptor, maps to a genetic region involved in human prostate cancer. Current studies in the lab focus on the role of *Sumacan* in brain tumors. Bob, a postdoc, is screening drugs that block *Sumacan* function; Ming Li, a graduate student, is elucidating the functional pathways *Sumacan* is involved in; and Steve, a graduate student, is performing a mutational analysis of the *Sumacan* gene. These same studies can be applied to prostate cancer, thereby opening up potential avenues for funding through prostate cancer foundations.

Scope of work.

◆ Examine whether the functional pathway for *Sumacan* is present in human prostate cancer cells.

◆ Compare the expression of *Sumacan* in normal human prostate tissues and prostate cancers, and correlate expression levels with clinical outcome in prostate cancer.

◆ Identify mutations in *Sumacan* in patients with prostate cancer.

Strategy. Each person in the lab is already working on different aspects of *Sumacan* biology in brain tumors. In each case, the work will be applied to prostate cancer cell lines that we will obtain from Mike, a colleague in our department. We have identified two additional potential collaborators—Rajiv, a pathologist who studies human prostate tissues and cancers, and Kathy, a geneticist who studies human prostate cancer families. We will use funds from our current R01 grant to obtain preliminary findings. We plan to use these findings to obtain a second R01 grant to the laboratory.

Section 2: Objective

Statement. Investigate the possible role of *Sumacan* in prostate cancer.

Measure #1. Our experiments will provide preliminary evidence to either support or deny a role for *Sumacan* in prostate cancer.

Specification. The experiments we carry out will answer the following questions:

◆ Is *Sumacan* expressed in the prostate?

◆ Is *Sumacan* expressed in prostate cancer?

◆ Is there a difference between the expression of *Sumacan* in the prostate and in prostate cancer?

Measure #2. The results obtained by these experiments will generate publications and grants.

Specifications.

◆ At least two (one for each postdoc working on the project) research articles will be accepted for publication in a top-tier research journal in the field.

◆ A request to NIH for funds to continue the research begun receives a percentile score on first-round submission of at least 25 percent and subsequent funding on the resubmission.

Measure #3. People in the field are aware of our research.

Specifications.

◆ We will receive several requests for information about the research.

◆ We will publish at least two research articles in the scientific literature.

◆ We will present the research results at at least two conferences in one year.

Section 3: Constraints
Limitations.

◆ The NIH proposal is due June 1, 2007. This means that the first research manuscript must be submitted for publication by approximately January 1, 2007, and accepted by mid-April 2007.

◆ Our lab has limited funds to cover the generation of preliminary data, which means that productivity has to be reviewed monthly.

Needs.

◆ Our lab needs to be able to grow prostate cancer cells.

◆ Our lab needs to be able to handle human prostate cancer specimens.

Section 4: Assumptions
◆ The current research team will be willing and able to perform prostate cancer studies in addition to their brain tumor studies.

◆ The collaborators we have identified will be willing and able to work with our group or will provide the name of another person who wants to collaborate.

The Work Breakdown Structure

Activity 1: Determine whether *Sumacan* is expressed in the prostate.

1. Determine where to obtain human prostate cells.

2. Determine how to grow human prostate cells.

   ◆ The type of medium and serum they require

   ◆ The optimal conditions for growth

3. Determine whether we can isolate RNA and protein from human prostate cells.

   ◆ Try the same technique we use to isolate RNA from brain cells.

   ◆ Develop a different technique.

4. Determine whether we can perform quantitative RT-PCR for *Sumacan* expression.

   ◆ Primers and positive and negative controls

5. Determine whether we can perform a Western blot for *Sumacan* expression.

   ◆ Test whether the antibody we use in the brain works in the prostate and determine what size protein band(s) is identified.

   ◆ Identify positive or negative controls for protein quality and *Sumacan* identification.

Note: Steps 1 to 3 must be done sequentially, but once step 3 is completed, steps 4 and 5 can be done at the same time.

Activity 2: Determine whether *Sumacan* is expressed in prostate cancer cells.

1. Determine where to obtain human prostate cancer cells.

2. Determine how to grow human prostate cancer cells.

   ◆ Type of medium and serum they require

   ◆ Optimal conditions for growth

3. Determine whether we can isolate RNA and protein from human prostate cancer cells.

   ◆ Try the same technique we use to isolate RNA from brain cells.

   ◆ Develop a different technique.

4. Determine whether we can perform quantitative RT-PCR for *Sumacan* expression.

◆   Primers and positive and negative controls

5. Determine whether we can perform a Western blot for *Sumacan* expression.

◆   Test whether the antibody we use in the brain works in prostate cancer cells and determine what size protein band(s) is identified.

◆   Identify positive or negative controls for protein quality and *Sumacan* identification.

Note: Steps 1 to 3 must be done sequentially, but once step 3 is completed, steps 4 and 5 can be done at the same time. In addition, activities 1 and 2 can be done at the same time, although this may result in higher resource costs if both tasks fail.

Activity 3: Determine whether there is a difference in *Sumacan* expression between normal and cancer cells.

1. Determine the difference in RNA expression.

2. Determine the difference in protein expression.

3. Determine the relationship between RNA and protein expression.

Note: Activity 3 involves analysis of the data collected in activities 1 and 2 and thus cannot be performed until these two activities are completed.

An Activities Plan

Activity	Person Responsible	Start Date	End Date	Notes
Identify sources of prostate cells	Theresa	Aug. 1	Aug. 5	
Identify sources of prostate cancer cells	Bob	Aug. 1	Aug. 5	
Grow prostate cells	Theresa	Aug. 5	Aug. 26	
Grow prostate cancer cells	Bob	Aug. 5	Aug. 26	
Isolate RNA and protein from prostate cells	Theresa	Aug. 26	Sept. 26	
Isolate RNA and protein from prostate cancer cells	Bob	Aug. 26	Sept. 26	
Perform RT-PCR on prostate cells	Theresa	Sept. 26	Oct. 26	
Perform RT-PCR on prostate cancer cells	Theresa	Sept. 26	Oct. 26	
Perform Western blots on prostate cells	Bob	Sept. 26	Oct. 26	
Perform Western blots on prostate cancer cells	Bob	Sept. 26	Oct. 26	
Compare the levels of *Sumacan* RNA in the prostate and prostate cancer cells	Theresa and Bob	Oct. 26	Nov. 5	
Compare the levels of *Sumacan* protein in the prostate and prostate cancer cells	Theresa and Bob	Oct. 26	Nov. 5	
Compare the levels of *Sumacan* RNA and protein with each other	Theresa and Bob	Oct. 26	Nov. 5	

Note: Each of these activities can be broken down further if more detail is needed. For example, if the activities are being performed by a new graduate student, you may want to explain the different protocols to use to perform RT-PCR from prostate cancer cells and what controls should be used as well as alternative protocols to use in case the first ones do not work.

A Gantt Chart

Activity	August	September	October	November	Person responsible
SUMACAN EXPRESSION IN PROSTATE CELLS					
Find cells Grow cells	▓				Theresa Theresa
Isolate RNA and protein		▓			Theresa
RT-PCR and Western blots			▓		Theresa and Bob
SUMACAN EXPRESSION IN PROSTATE CANCER					
Find cells Grow cells	▓				Bob Bob
Isolate RNA and protein		▓			Bob
RT-PCR and Western blots			▓		Theresa and Bob
COMPARE RESULTS					
Data Analysis				▓	Theresa, Bob and PI

A Loading Chart

This chart displays Theresa's workload. She is responsible for the first three steps in determining *Sumacan* expression in prostate cells. Step 1 (looking for prostate cells) is done in week 1, step 2 (trying to grow the cells) in weeks 2 to 4, step 3 (isolating RNA and protein) in weeks 5 to 8, and step 4 (doing RT-PCR on normal and cancer cells) in weeks 9 to 13. In addition, during the time the project is being run, she will be teaching a microbiology lab course (5 hours/day with monthly exams).

Weeks	1	2	3	4	5	6	7	8	9	10	11	12	13
Research Hours	7	10	10	10	8	8	8	10	25	25	25	25	25
Microbiology Lab Hours	25	25	25	35	25	25	25	35	25	25	25	35	25
Total Time	32	35	35	45	33	33	33	45	50	50	50	60	50

Source: The examples in this appendix were provided by Milton W. Datta, Emory University School of Medicine.

Chapter 8

DATA MANAGEMENT AND LABORATORY NOTEBOOKS

As science explodes with new information and competition increases, and as academic scientists engage in more collaborations with industry scientists, proper recording of laboratory activities and managing the volumes of data produced by a laboratory are becoming increasingly important.

This chapter covers some of the basics: the importance of day-to-day record keeping and good practice for laboratory notebooks, what to consider when developing a system to track and store information, and finding the right data management system for you.

DAY-TO-DAY RECORD KEEPING: THE LAB NOTEBOOK

Why Keep Daily Records?

Every person working in a lab should keep detailed records of the experiments conducted each day. Here are some reasons why.

Establishing good work practices. Lab records allow your work to be reproduced by others. The records you keep should allow you and others to re-create the work and achieve the same results, thereby validating or extending your work. The records also allow you to prepare formal reports, papers, and presentations. They also serve as a source for assigning credit to lab members.

Teaching the people in your lab. Scientific training involves gathering information, forming hypotheses, designing experiments, and observing results. Lab notebooks, in which these activities are carefully recorded, can be a valuable aid in teaching your grad students, postdocs, and technicians how to analyze results, construct new theories and tests, and retrace their steps to identify an error.

> *Enter all your work in a notebook—even procedures that did not work.*
>
> —David Adams, Duke University Medical Center
>
> *Reading notebooks is a nonconfrontational way to keep current with your students' and postdocs' work, and notebooks are critical when these lab members leave.*
>
> —Joseph Vinetz, University of Texas Medical Branch–Galveston

Meeting contractual requirements. From grants to contracts to patent applications, researchers have explicit terms and implicit expectations to meet, for which detailed records and data are essential. For example, the National Institutes of Health has the legal right to audit and examine records that are relevant to any research grant award. Accordingly, the recipients of research grants have an obligation to keep appropriate records.

Avoiding fraud. Lab directors are responsible for the integrity of their lab and everything it produces. Periodic checks of raw data in notebooks and project files can uncover and correct carelessness or outright fraud before they become huge problems.

Defending patents. U.S. patent law follows a first-to-conceive rather than a first-to-file system. That is why documentation to support the date of discovery or invention is critical and why pages of lab notebooks and other records should be consecutively numbered, dated, and signed. Careful records can save a patent.

Question: For patent purposes, what's an "original" record?

Answer: An original is the first human-readable form—for example, a printout of a measurement but not a photocopy of it. It should be dated, signed, and filed.

Question: Genomics produces massive amounts of data. If the data are burned on a CD, are they considered "original"?

Answer: In this era of computer-assisted research, many pieces of data are collected, stored, and analyzed by computer. The problem with electronic records is that it is hard to prove that the data are not added to, deleted from, or in some way tampered with. The Food and Drug Administration (FDA) has published clear guidelines for maintaining electronic records in a way that will meet legal scrutiny (*http://www.fda.gov/ora/compliance_ref/part11*). If you have really important results, it is probably safer to print them out, sign and date the documents, and indicate why they are significant.

Good Practice for Laboratory Notebooks

Although individual scientists are responsible for maintaining their own notebooks, heads of labs are responsible for making sure that the notebooks of those under their direction are in order. The precise way in which to document scientific research varies from field to field and from institution to institution, but some general rules apply, such as the following:

◆ Use a permanently bound book, with consecutive signed and dated entries. When appropriate, witness entries as well.

◆ For computer-kept logs, you can use a loose-leaf notebook, but pages must be consecutively numbered (using a sequential page-number stamp), dated, and signed.

◆ Record entries chronologically.

◆ Each entry should stand on its own to permit others to replicate the work.

◆ Organize material with sections and headings.

◆ Identify and describe reagents and specimens used.

◆ Identify sources of those materials (e.g., reagent manufacturer, lot number, purity, expiration date).

◆ Enter instrument serial numbers and calibration dates.

◆ Use proper nouns for items.

◆ Write all entries in the first person, and be specific about who did the work.

◆ Explain nonstandard abbreviations.

◆ Use ink and never obliterate original writing; never remove pages or portions of a page.

◆ If a page is left blank or a space within a page is left blank, draw a line through it.

◆ Permanently affix with glue any attachments (such as graphs or computer printouts) to the pages of the notebook; date and sign both the notebook page and the attachment.

◆ Outline new experiments, including their objectives and rationale.

Electronic Laboratory Notebooks

Electronic laboratory notebooks (ELNs) do everything their handwritten forebears do but with the attractive bonus of search and organization functions. Through links to analytical software, ELNs can usually download and store data directly, and many ELNs also support secure access for multiple users and remote users.

Choosing the right ELN for your lab requires homework. One important consideration is whether the ELN complies with the FDA's rules for acceptance of electronic documents, which were published in March 1997 in title 21 of the Code of Federal Regulations, part 11, available online at *http://www.fda.gov/ora/compliance_ref/part11*.

So far, few ELNs have been subjected to legal scrutiny, and it is doubtful that many would pass the test. For this reason, most researchers in academic and industry settings are sticking to paper records.

◆   Include periodic factual, not speculative, summaries of status and findings.

◆   Enter ideas and observations into your notebook immediately. Summarize discussions from lab meetings and ideas or suggestions made by others, citing the persons by name.

Question: Why should I learn to write in the notebook?

Answer: You want to create an accurate, original, permanent record. There is a tendency to record information on the handiest piece of paper available, even on a paper towel lying on a bench, and then later transferring the information to a notebook. Therefore, you should get into the habit of immediately recording data as they are being collected into your lab notebook.

Question: What's the responsible way to document errors?

Answer: Make the required changes as soon as possible without obliterating the original entry. Electronic documents may require a new entry, not an override. If the error is logged by hand, do not erase or alter the initial entry. Correct the data at the point in the log where the error was discovered, refer to the original page, and go on (e.g., "Reagent was 50 percent of the strength we originally thought.").

Question: How do I get people in my lab to keep good records?

Answer: All students, technicians, and postdocs should be issued their own laboratory notebooks, with instructions on how to record in them. Establish expectations early and reinforce them periodically. The job interview is not too early to describe expected lab record-keeping methods and media. Many lab heads have a system for regularly reviewing all lab notebooks.

When Is a Witness Warranted?

Some companies require that all notebook pages be witnessed. In academia, few labs follow this practice, but under some circumstances, having a certain record signed by a witness is desirable.

Learn to recognize an entry that merits a witness. When you think you have conceived an invention or an idea that may have intellectual property value, the date you did so is when you want a witness. For example, if lunch with a colleague leads you to an idea so tantalizing that you simply must go write it down, that's a notebook page you want witnessed. Another important date from a patent law standpoint is when the idea is put into actual practice, called "reduction to practice" (see chapter 11, "Understanding Technology Transfer").

Learn who constitutes an appropriate witness. Although a witness serves a certifying function much like a notary public, unlike a notary, a witness needs a sound grasp of the science. However, the witness should not be a coinventor, who, from a legal perspective, has a vested interest in verifying the claim. Find someone who is not directly involved in your work but who understands and can explain your idea. You may also need different people to witness pages containing different ideas. Do not designate one person as the "official" witness in your lab. Rote signatures unsupported by suitable scientific credentials will not meet the standard for credibility in court.

Where and How Long to Keep the Notebook

Lab notebooks that are "in progress" should be kept in the lab and reviewed periodically. Usually, notebooks are kept on a lab bench, but if you are concerned about the risk of damage or contamination, make it a rule that at the end of each day, all lab notebooks are placed in a fireproof cabinet or other designated space.

Completed lab notebooks should be indexed and kept in a safe central repository, along with corresponding patent applications or patents. Notebooks should be catalogued. Every time someone takes a notebook, it should be checked out and then returned. A person who is leaving the lab for a position elsewhere should not take any original lab notebooks but could be allowed to take copies of the lab notebooks he or she has maintained.

In general, the principal investigator should keep notebooks for at least five years after funding for the study ends. At that point, the notebooks can continue to be stored on site or moved to a storage facility. For anything that has been patented, the general rule is that the corresponding lab notebooks should be kept for the life of the patent plus six years. Your institution may have specific policies for you to follow. If you move to a new institution, you should also check your old institution's policies; some institutions require departing faculty to leave their original lab notebooks.

> *Every gel should be dried down and put in the lab notebook—even negative results.*
>
> —Joseph Vinetz, University of Texas Medical
>   Branch–Galveston

TRACKING AND STORING INFORMATION

Developing a Data Management System

Take the time to think about and produce a plan to track and store data generated by the people in your lab. Some requirements of your system will include the following:

◆   *Ability to sort and search:* If you want to be able to sort data in your system by a particular criterion, the information has to be entered as a sortable field. Try to identify at the beginning all the ways you might want to retrieve your data later. This is a challenging but productive exercise in thinking ahead.

◆ *Consistency:* For comparability, you need standards that are followed consistently. If everyone in your lab uses a different document-naming protocol, the departure of one person can create chaos. Decide on a consistent system for the file names of electronic and paper documents as well as the identification of samples and specimens—everything that your lab catalogues and stores. Figures 8.1 and 8.2 (page 149) present examples of alphanumeric coding systems for electronic documents and specimens.

◆ *Ability to update records:* It is important that you set up a system for logging in reagents and that everyone in the lab uses the system.

Assign Responsibility

It's not enough to have a data management plan; someone needs to make sure the plan is executed. Because this is your lab, it's your responsibility—to handle personally or to delegate. Once you have made that choice, put quality assurance procedures in place, including scheduled spot checks of your established procedures. Make sure that everyone in your lab knows what to store where, how to do it, and who needs to log in that information.

What to Store and How

You will likely want to store the following:

◆ Lab protocols

◆ Primary data, including images

◆ Lists of specimens and reagents

◆ Information about instruments

Where and how long you keep this information will likely be dictated by the type of information, but you also need to consider issues of lab space, fees and security issues for off-site storage, and the shelf life of the materials being stored. Here are some general guidelines.

Printed records. Records written in ink on acid-free paper and laser-printed records can be archived for a long time; ideal conditions are approximately 50 percent relative humidity and 21°C or cooler.

Electronic records. In theory, CD-ROMs and DVDs can last more than 200 years when stored in the dark at 25°C and 40 percent relative humidity. Floppy disks, however, have a shelf life of only about three years. Similarly, magnetic media are not designed for long-term storage. Another point to consider is whether the hardware and software needed to read the information will be available in the long term.

**Figure 8.1.
Electronic
document file
names**

CR0216G XRD01 A347.xls

Project number

File type:
D = data
G = graph
L = letter
P = proposal

Sample

CR0216L Kanare prelim stats02.doc

Project number

Addressee

Title
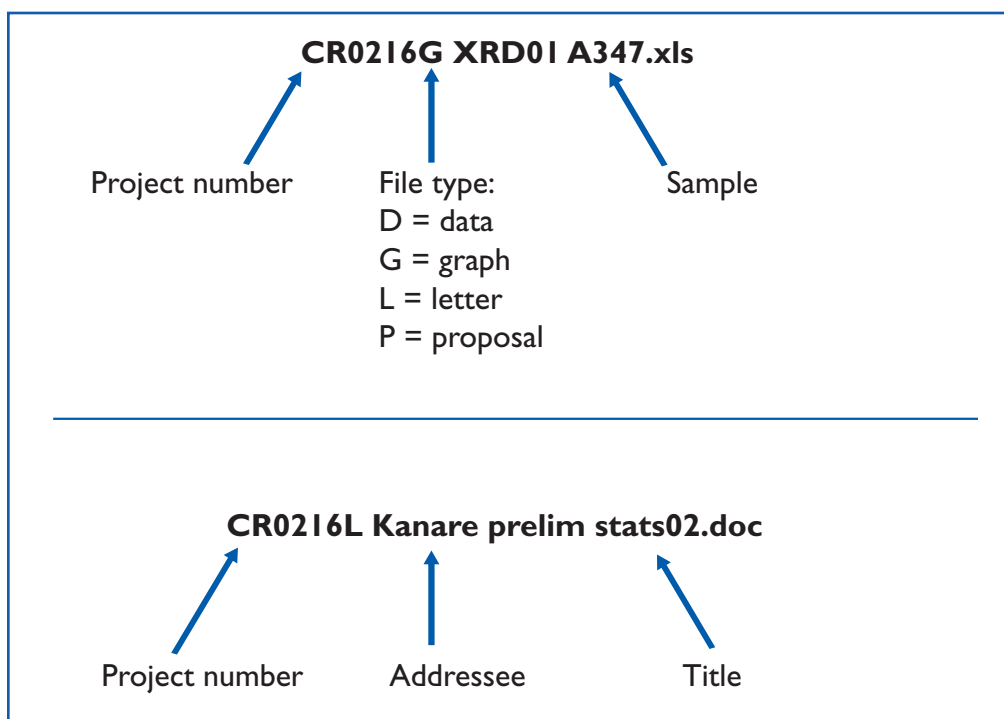
Source: Howard Kanare, Construction Technology Laboratories.

**Figure 8.2.
Sample and
specimen IDs**

CR0216-0027a.xls

Project number

Sequential
sample ID number
(from spreadsheet log)

Split (a, b, c, etc.)

Kanare001-132-6a

Notebook number

Page number

Sequential number, on
page and split
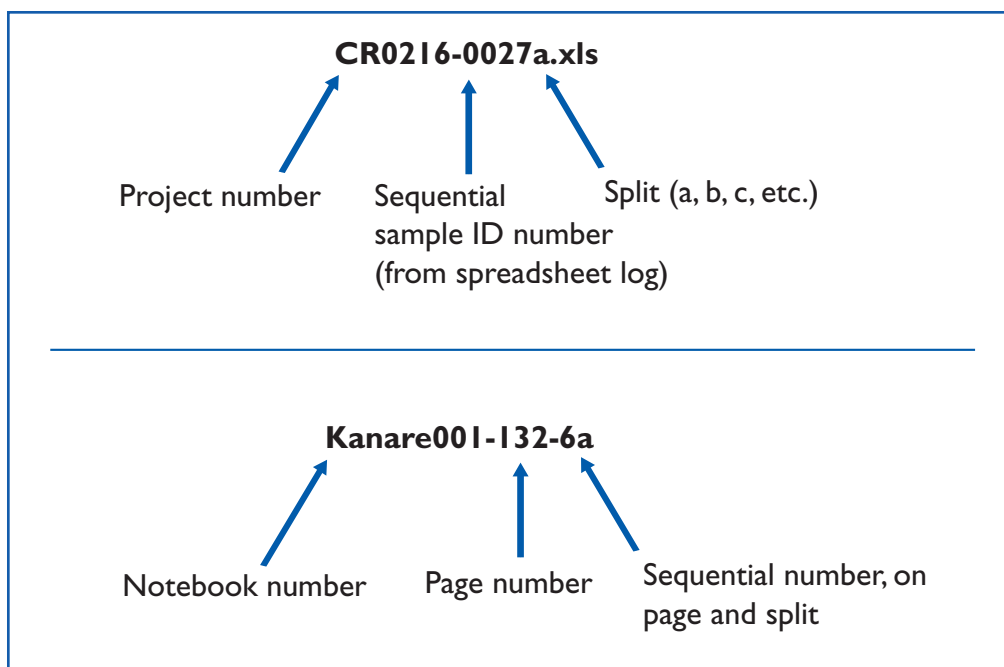
Source: Howard Kanare, Construction Technology Laboratories.

Lab protocols. Many labs keep a master collection of lab protocols, which is available either electronically or in print and is updated periodically. Lab protocols are rarely the type of records you need to store for the long term.

Reagents. It is important to have a system in place for keeping track of reagents that are used in your lab. While work is in progress, maintain records about the reagents used and keep the reagents themselves easily accessible in storage. Database programs such as FileMaker are easy to use and useful for keeping track of items such as oligos, antisera, plasmids, and cell lines. Many labs also use Excel spreadsheets or even paper records. When people leave the lab, have them place their unique reagents in storage boxes and document their location. Make sure everyone in the lab updates the database regularly.

You will also need a reliable tracking system for the sharing of reagents—requesting them from other sources and transferring yours to other labs. This involves Request for Materials forms and Material Transfer Agreement forms (see chapter 11, "Understanding Technology Transfer").

Instrument histories. The care and maintenance of equipment are important responsibilities that affect the entire lab. Make sure someone accepts them and follows through. Lab records should include instrument logs that contain purchase, upgrade, and repair information; a calibration schedule and results; a control chart for performance trends; and blind quality control and assurance checks.

FINDING THE RIGHT DATA MANAGEMENT SYSTEM FOR YOU

Many academic labs, especially small ones, track samples, reagents, and experiments through paper records and simple electronic spreadsheets. But as the amount and complexity of data grow, some investigators may turn to specialized software products, such as databases, laboratory information management systems (LIMS), archival software, and tools to integrate the different applications.

Selecting a suitable program—one that fits your lab's needs and budget—involves something at which you excel: research. Consult colleagues who have been through this process themselves, and don't be shy about involving your institution's information technology office. Once you have narrowed the list of candidate software, arrange vendor demonstrations and visits to labs that use these systems, and, of course, conduct reference checks. Your institution's purchasing office may also be helpful.

Some of the questions that you should consider are

◆   Is the system compatible with your existing software and hardware? Will it interface with your instruments?

◆   Are other users satisfied? (Talk to people in your field who have purchased a system.)

◆   What kind of support is available from the vendor?

◆ How much flexibility does the system offer? Can it be configured to satisfy your particular needs?

◆ How much training will be required?

◆ Is the company that sells the system well established or is it likely to be out of business in a few years?

◆ Is it worth it, or can you get by with the system you already have? Do you really need more software?

> *Redundancy is good. Cross-reference data sources—files, documents, samples—according to whatever consistent alphanumeric or other system your lab uses.*
>
> —Howard Kanare, Construction Technology
> Laboratories

Databases

FileMaker Pro is an inexpensive, easy-to-use software program that allows users to create a custom database in minutes and is a favorite among researchers. Some use it for ordering lab supplies. It allows lab members to keep track of what has been ordered, by whom, and when, as well as how much money has been spent. In addition, its search feature allows users to quickly locate items that have been ordered before without having to look them up in the catalog. Other researchers use it to keep a record of all constructs, plasmids, cells, and so on, in the lab and where they are located. You can customize almost every area of FileMaker to work the way you do, so you're not forced to manage your information in a pre-set way. The software works on both Mac and PC, and FileMaker information can also be accessed on the Web. The latest version of the software, FileMaker 8, lets you store any kind of files in your database, including Word files, movies, images, and PDFs. Data can be sent to others as Adobe PDF or Excel files.

Laboratory Information Management Systems

Traditionally, LIMS have been used by chemistry labs that conduct batteries of tests on thousands of samples. In recent years, however, the LIMS marketplace has unveiled new products adaptable to the specialized needs of life sciences research (e.g., microbiology and genomics). LIMS can be used to

◆ Receive, log in, and label samples.

◆ Assign work (e.g., tests and analyses for each sample).

◆ Schedule work.

◆ Check status of work.

◆ Integrate data collection by interfacing with instruments.

◆ Track records and specimens.

Be aware that a flexible system may not be ready for use straight out of the box. You may have to configure it to your specifications first.

Archival Software

The multitude of data generated by a single lab can be overwhelming. A growing number of software systems allow the user to collect, store, and visualize disparate kinds of information—ranging from mass spectrometry readings to microarray data. The systems provide a central repository for all data generated in a lab. One of the critical features that sets different types of software apart is the degree to which stored data can be retrieved and manipulated in the absence of the original instrument software. Another important consideration is the degree to which the stored data meet the FDA criteria set forth in title 21 of the Code of Federal Regulations, part 11 (see box "Electronic Laboratory Notebooks," page 145).

As principal investigator, you know that maintaining accurate and consistent laboratory records and managing the flow of data your lab generates are critical to the success of your research program. So, be proactive. As you're setting up your lab, determine the standards and procedures for record keeping and communicate these to the members of your lab. Develop a plan to efficiently track and store data and find an electronic data management system to help you implement this plan. Once you've done this, you're well on your way to keeping the avalanche of data organized and retrievable.

RESOURCES

American Association for the Advancement of Science. Scientific integrity videos, *http://www.aaas.org/spp/video/orderform.htm*.

Barker, Kathy. *At the Bench: A Laboratory Navigator.* Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press, 1998.

Barker, Kathy. *At the Helm: A Laboratory Navigator.* Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press, 2002.

Food and Drug Administration. Title 21 Code of Federal Regulations, part 11 (21 CFR part 11), Electronic Records; Electronic Signatures, *http://www.fda.gov/ora/compliance_ref/part11*.

Harmening, Denise M. *Laboratory Management: Principles and Processes.* Upper Saddle River, NJ: Prentice Hall, 2003.

Kanare, Howard M. *Writing the Laboratory Notebook.* Washington, DC: American Chemical Society, 1985.

Chapter 9

GETTING FUNDED

You've begun your career as an academic scientist. Your lab is up and running, and your research program is under way. But the pressure is on—soon you will have to find financial support for your research from sources other than your institution. It's time to learn the art of getting funded.

Numerous public and private sources support scientific studies, but the National Institutes of Health (NIH), a component of the Public Health Service under the U.S. Department of Health and Human Services, is by far the nation's largest funder of academic research. For that reason, this chapter focuses primarily on NIH and emphasizes the R01 grant, an investigator-initiated research project grant for which most beginning academic investigators will have to apply.

This chapter provides an overview of the NIH funding process and the two-level review system that is used by NIH for most R01 grant applications. It also details the steps involved in preparing a strong R01 grant application, including turning your concept into a solid research plan and making sure that individuals with the appropriate expertise review your application. In addition, the chapter discusses what to do if your application is not funded. The chapter also provides some information about another major funder of basic science research, the National Science Foundation (NSF).

> *There is no grantsmanship that will turn a bad idea into a good one, but there are many ways to disguise a good one.*
>
> —William Raub, former deputy director, NIH

UNDERSTANDING THE NIH FUNDING PROCESS

NIH Institutes and Centers

An important part of writing a successful grant application is having a good understanding of the mission of the funding organization and the type of projects it supports. At this point in your career, you are probably already familiar with NIH and may have even applied for NIH postdoctoral funding. However, it's still useful to remember that NIH is composed of institutes and centers (I/Cs) whose numbers increase and whose structures are reorganized periodically. (From a grant applicant's perspective, the only relevant distinction between institutes and centers is that an institute can make awards of less than $50,000 without approval from its national advisory council, but a center cannot.) As of May 2006, NIH had 20 institutes and 7 centers. Each I/C has its own mission and research agenda, and 24 of the current 27 I/Cs have funding programs for extramural awards (research conducted outside their own facilities and staff), including those that fund R01 grants. Although not essential, it will be useful for you to identify an I/C that is likely to be interested in your research (see "Find a Home for Your Application at NIH," page 164).

Question: At what stage in my career should I apply for my first R01 grant?

Answer: After you have accepted a position at a university or medical center, you may be encouraged by your department chair to apply for your first NIH grant, even before you move into your new lab. Some experts warn, however, that it might be better to wait until the second year of your appointment, because it will help your application considerably if you have generated some preliminary data in your new lab. Whenever you decide to apply, remember that you are in that special position of "new NIH investigator" only once; make the most of it.

Question: What's the difference between an RFA and a PA?

Answer: An RFA invites grant applications in a well-defined scientific area for which an I/C has determined a specific research need (e.g., to study West Nile virus). This is usually a one-time competition and funds are set aside for a certain number of awards. A PA invites grant applications for a scientific area for which an extramural research program within an I/C has new or expanded interest or continuing interest (e.g., to study drug addiction). These applications are accepted on standard receipt dates on an ongoing basis.

The R01 Review: An Overview

R01 grant applications are usually investigator-initiated. Applications can also be submitted in response to a Request for Applications (RFA) or a Program Announcement (PA), both of which are announced in the NIH Guide for Grants and Contracts (*http://grants.nih.gov/ grants/guide/index.html*). R01 applications submitted in response to an RFA are generally reviewed by the issuing I/C. R01 applications submitted in response to a PA are reviewed by the Center for Scientific Review (CSR). Regardless, all applications are sent to the CSR and then follow a two-level review process: CSR 1) assigns the application to a Scientific Review Group (SRG) for evaluation of scientific and technical merit and 2) assigns it to one or more I/Cs to review for programmatic relevance and funding recommendations. (Figure 9.1 provides an overview of this two-level review process.) CSR conducts scientific peer review of approximately 70 percent of the applications sent to NIH; I/Cs evaluate the others. Of the more than 68,000 applications received annually by NIH, perhaps only 20 to 25 percent are funded. The funding range can vary from year to year and from one I/C to another.

**Figure 9.1.
Overview of
the NIH R01
grant review
process**

```
┌─────────────────────────┐
│ NIH/CSR receives        │
│ application             │
└─────────────────────────┘
            │
            ▼
┌─────────────────────────┐        ┌─────────────────────────┐
│ CSR assigns application │        │ CSR sends PI confirmation│
│ to SRG and Institute or │───────▶│ of receipt (also called  │
│ Center (may assign to   │        │ assignment notification  │
│ more than one I/C)      │        │ letter)                  │
└─────────────────────────┘        └─────────────────────────┘
            │
            ▼
┌─────────────────────────┐
│ SRG  (study section)    │
│ conducts review for     │
│ scientific merit and votes│
│ a priority score        │
└─────────────────────────┘
            │
            ▼
┌─────────────────────────┐        ┌─────────────────────────┐
│ SRA prepares summary    │        │ If application is in funding│
│ statement of review     │───────▶│ range, PI receives letter │
│ results, sends to       │        │ notifying of need to get  │
│ PI and I/C              │        │ IRB and IACUC approval    │
│                         │        │ if not already obtained   │
└─────────────────────────┘        └─────────────────────────┘
            │
            ▼
┌─────────────────────────┐
│ I/C national advisory   │
│ council conducts review │
│ for program relevance and│
│ funding; makes          │
│ recommendation          │
└─────────────────────────┘
            │
            ▼
┌─────────────────────────┐
│ I/C director, acting on │
│ behalf of NIH director, │
│ takes final action to fund│
│ or not                  │
└─────────────────────────┘
            │
            ▼
┌─────────────────────────┐
│ I/C notifies PI of      │
│ final action            │
└─────────────────────────┘
```

CSR: Center for Scientific Review
IACUC: Institutional Animal Care and Use Committee
I/C: NIH Institute or Center
IRB: Institutional Review Board
PI: Principal Investigator
SRA: Scientific Review Administrator
SRG: Scientific Review Group

Common Abbreviations

AREA: Academic Research Enhancement Award

CRISP: Computer Retrieval of Information on Scientific Projects

CSR: Center for Scientific Review

IACUC: Institutional Animal Care and Use Committee

I/C: NIH Institute or Center (also written IC)

IRB: Institutional Review Board

IRG: Integrated Review Group

OER: Office of Extramural Research

OHRP: Office for Human Research Protections (formerly OPRR, Office of Protection from Research Risks)

OLAW: Office of Laboratory Animal Welfare (formerly Division of Animal Welfare within OPRR)

PA: Program Announcement

RFA: Request for Applications

RFP: Request for Proposals

SEP: Special Emphasis Panel

SRA: Scientific Review Administrator

SRG: Scientific Review Group

First-Level Review: Scientific Review Group

One type of SRG, the study section, is used by CSR to review R01 grant applications. Study sections are clustered into Integrated Review Groups (IRGs), organized around a general scientific area. Each study section has a specific scientific focus. (For simplicity, the terms study section and SRG are used interchangeably in this chapter.)

R01 applications are usually assigned first to an IRG and then to a study section within that IRG. The study section reviews the grant application for scientific merit, rates it with a numerical priority score from which a percentile ranking is derived, and recommends an appropriate level of support and duration of award.

Scores, ranks, and percentiles. Every member of a study section gives each application a rating, or priority score. Those scores are averaged to create a three-digit number, which is that application's final score in the NIH computer system. A 100 is the best possible score, and a 500 is the worst possible score. Some applications are not discussed at the review meeting and thus do not receive a score (see "Streamlining and Deferrals," page 158).

Percentiling is a reflection of the rank of a particular score in the pool of all scores given by a study section in its current meeting plus the two previous meetings. For example, an application whose score ranked number 50 out of 100 applications would receive a percentile of 49.5, according to the following formula:

$$P = 100 \times (R - \tfrac{1}{2}) / N$$

In the formula, P is the percentile, R is the ranking (in this case, 50), and N is the total number of applications.

The percentiling process is specific to each study section and is the way that NIH I/Cs can account for different scoring behavior in the various study sections. Thus, if the 20th percentile is a 150 priority score in Study Section A and a 190 priority score in Study Section B, both applications are considered in the 20th percentile and treated as such when funding decisions are made by the I/Cs.

Behind Closed Doors: Demystifying the Study Section

Chartered study sections

◆　Are managed by a scientific review administrator (SRA), a professional at the M.D. or Ph.D. level with a scientific background close to the study section's area of expertise.

◆　Have 12 to 24 members recruited by the SRA, most of whom are from academia—some have long-term appointments and others are temporary members.

◆　Review as many as 60 to 100 applications per meeting.

◆　Usually assign three reviewers to each application.

◆　Are supported by a grants technical assistant, who reports to the SRA.

Under the terms of the Federal Advisory Committee Act, study section meetings are closed. Meetings include

◆　Orientation (discussion of general business)

◆　Provisional approval of list of streamlined applications

◆　Discussion of remaining applications

The discussion of applications includes the following:

◆　Reviewers with a conflict of interest are excused.

◆　Assigned reviewers present strengths, weaknesses, and their preliminary scores.

◆　Other members discuss scientific and technical merit.

◆　Range of scores is expressed (every member scores every application).

◆　Codes for gender, minority, and children and human subjects are assigned (NIH has requirements for inclusion of women, minorities, and children in clinical research and strict criteria for research involving human subjects and animals).

◆　Recommended budget changes are discussed.

After each meeting, the SRA documents the results in a summary statement, which is forwarded to both the I/C and the principal investigator.

Summary statements may vary somewhat depending on the SRA, but all of them contain

◆　Overall résumé and summary of review discussion (for applications that were discussed and scored)

◆　Essentially unedited critiques by the assigned reviewers

◆　Priority score and percentile ranking

◆　Budget recommendations

◆　Administrative notes (e.g., comments on human subjects or animal welfare)

For more information about what happens in a study section, see the CSR Web site (*http://www.csr.nih.gov*). Also, professional societies, such as the American Society for Cell Biology, often conduct mock study sections at their meetings using already-funded applications.

Poor priority scores. Applications can receive poor priority scores for any number of reasons, including the following:

◆ Lack of original ideas

◆ Absence of an acceptable scientific rationale

◆ Lack of experience in the essential methodology

◆ Questionable reasoning in experimental approach

◆ Diffuse, superficial, or unfocused research plan

◆ Lack of sufficient experimental detail

◆ Lack of knowledge of published relevant work

◆ Unrealistically large amount of work for the given time frame or funding level

◆ Uncertainty about future directions

Question: What should I do if an SRA asks me to be a reviewer for a study section?

Answer: Views differ on this question. Service on a study section can provide valuable insights for grant writing and open professional doors in other ways. However, many senior scientists counsel that junior faculty should wait until they have obtained tenure before accepting an invitation to be appointed to a term on a study section, because they should be devoting their energies to their research, which is the primary basis for the tenure decision. However, agreeing to serve as a temporary member might be appropriate at this stage in your career.

Streamlining and deferrals. A study section gives a score to only about half the applications assigned to it every review cycle. Through a process called "streamlining," applications that are deemed by reviewers to be in the lower half of those assigned for review are read by the assigned reviewers and receive written critiques, but they are not scored or discussed at the review meeting. Any member can object to the streamlining of any application, thereby bringing it to full discussion at the meeting. Streamlining was instituted to allow more time for discussion of applications near the fundable range and to shorten the meetings. This more efficient process also helps attract more reviewers.

A study section can also defer an application if, for example, more information is needed before the reviewers can adequately consider the application. Deferred applications require a majority vote by the study section and are rated "DF." Deferrals are rare.

Second-Level Review: I/C National Advisory Council or Board

After an R01 application has undergone study section review, it undergoes a second-level review by the national advisory council or board of an I/C. The advisory council is composed of people outside the I/C. Approximately two-thirds are scientific members who are generally established in their fields, such as deans or department chairs. Others are advocates for specific health issues and patient populations, ethicists, and laypersons. The secretary of Health and Human Services has ultimate authority to make these appointments.

The advisory council assesses the quality of the study section's scientific review, makes recommendations to I/C staff on funding, and evaluates the application's relevance to program priorities. For every scored application, the advisory council will do one of the following:

◆ Concur with the study section's action.

◆ Modify the study section's action (but it cannot change the priority score).

◆ Defer the study section's action for another review, with no changes allowed (e.g., if the principal investigator has appealed, the council may recommend a re-review because it considers the first review flawed).

The I/C director, acting on behalf of the NIH director, takes final action. Awards are made on the basis of scientific merit, program considerations, and available funds. The director usually (but not always) follows the advisory council's recommendations.

Roughly half of the funding I/Cs post their funding plans on their Web sites. The funding plan is the percentile to which the I/C anticipates being able to fund applications on the basis of its budget, recent funding history, and program priorities. If that information is posted, you can check the Web site after you receive the summary statement that shows your application's percentile. Regardless of whether the I/C to which your application was assigned posts its funding plan, you may want to ask the I/C program official responsible for the administrative management of pending applications/revisions and funded grants about the likelihood of your obtaining funding.

Review and Funding Cycles

The meetings of the national advisory councils form the basis for NIH's three overlapping review and funding cycles (see figure 9.2). However, NIH is trying to expedite the funding process by making some awards before the council meeting. For example, a candidate for expedited funding might be an R01 application that has a high score, is in an area of strong interest, and does not involve human subjects.

Figure 9.2. Typical timeline for a new R01 application

	Cycle 1	Cycle 2	Cycle 3
Application Submitted	February	June	October
SRG (Study Section) Review	June	October	February
Advisory Council Review	September	January	May
Earliest Award	December	April	July

Note: This timeline is specific to R01 research grants. Always check with the I/C to verify due dates for specific types of applications. RFA due dates are stated in the solicitations.

Depending on the I/C, approximately 30 percent of funds are allocated at each of the first two meetings; more is spent at the third meeting. Some I/Cs may be a bit more conservative in funding (e.g., to the 25th percentile) in the first two cycles to hold funds in reserve in case strong applications are submitted during the final funding cycle. In addition, every advisory council and I/C staff have "select pay" for which they can nominate applications that have poorer scores but are of high interest for funding.

As much as possible, consider the timing of your application in terms of the career track at your institution. You want to be funded when decisions about tenure are made.
.

Opportunities for Beginning Investigators

NIH actively seeks to support beginning investigators. When you apply for your first NIH grant, check the box on the form that signals to reviewers that you're a new investigator (meaning you haven't been principal investigator on an NIH research grant before). The reviewers are often more forgiving of applications from novices.

Other, non-R01 research awards available specifically to beginning investigators include

- ◆ Mentored Research Scientist Development Award (K01)

- ◆ Independent Scientist Award (K02)

- ◆ Mentored Clinical Scientist Development Award (K08)

- ◆ Small Grant (R03)

- ◆ Academic Research Enhancement Award (R15)

- ◆ Exploratory/Developmental Grant (R21)

- ◆ Career Transition Award (K22)

Many of these programs are announced periodically in the NIH Guide to Grants and Contracts (*http://grants.nih.gov/grants/guide/index.html*). Each has its own criteria for eligibility and submission of applications. Information on these and other NIH extramural funding opportunities can be found at *http://grants.nih.gov/oer.htm*.

In addition to NIH, other federal agencies and private sector organizations solicit and fund research grants, and each has its own application and review system (see "Resources," page 173). You can send the same application to multiple funding sources in the public and private sectors, but you must disclose your multiple applications to each potential funder to avoid "double dipping" when awards are made.

PREPARING A STRONG GRANT APPLICATION

Getting Started

Successful grant applications begin with a good idea. Figures 9.3 and 9.4 (pages 162 and 163) show the sequence of steps that can carry you from a good idea through the submission of an application to the final decision about funding.

Once you have a good idea, you can get started in two realms: your own institution and an appropriate NIH I/C. These activities overlap to some extent, but they are presented sequentially below.

Seek input at your own institution. An experienced scientific reviewer and NIH grantee recommends seeking peer review of your research proposal at your own institution according to a plan devised by Keith Yamamoto, University of California–San Francisco. The process, which begins at least two months before the application deadline of your grant, involves the following steps:

1. Choose three senior colleagues as your "grant committee." Ideally, these would be successful grantees and would include someone who has experience on a study section.

2. Discuss research goals, aims, and ideas with the committee (1.5 hours).

3. Draft one page listing three to five specific aims, and explain why each aim is important.

4. Discuss your aims and rationales with the committee (1.5 hours).

5. Refine your aims according to committee comments.

6. Draft the abstract and the research design and methods sections. Then draft the progress report and the background and significance sections. (See box "Components of the NIH R01 Grant Application" and "Preparing Your Application," page 166.)

7. Read "Criteria for Rating of NIH Grant Applications" (page 167), and revise your drafts as appropriate.

8. Seek feedback on the drafts from your committee.

In addition to seeking advice from other scientists, seek administrative advice from appropriate review bodies, such as your local Institutional Review Board and Institutional Animal Care and Use Committee.

Components of the NIH R01 Grant Application

◆ **Research Plan:** Abstract, Specific Aims, Background (like a review article), and Significance

◆ **Progress Report** (preliminary results and demonstration of relevant expertise)

◆ **Research Design and Methods**

◆ **Resources and Facilities**

◆ **Budget**

◆ **Budget Justification**

Tip: Conclude each section in the research plan with a few sentences stating what you will learn and why that information is important—for example, "These experiments are important because nothing is known about X, and they will enable us to distinguish between two controversial models that are widely discussed in the field."

For information about how to prepare a grant application form, visit http://grants.nih.gov/grants/grant_tips.htm.

**Figure 9.3.
The
application:
From concept
to submission**

```
                        ┌─────────────────────┐
                        │  In the beginning:  │
                        │   The good idea     │
                        └─────────────────────┘
                          │                 │
                          ▼                 ▼
        ┌─────────────────────┐   ┌─────────────────────┐
        │ Seek input at your  │   │ Find a home for your│
        │ own institution     │   │ research; investigate│
        │                     │   │ suitable I/Cs       │
        └─────────────────────┘   └─────────────────────┘
                          │                 │
                          ▼                 ▼
                    ┌─────────────────────┐
                    │ Write an abstract (clear │
                    │ language suitable for │
                    │ educated layperson) │
                    └─────────────────────┘
                              │
                              ▼
        ┌─────────────────────┐         ┌─────────────────────┐
        │ Contact the program │◀────────│ If discouraged, ask about │
        │ officer at the target│────────▶│ alternative I/C and │
        │ I/C(s)              │         │ program officer     │
        └─────────────────────┘         └─────────────────────┘
                              │
                              ▼
                    ┌─────────────────────┐
                    │ If encouraged, send │
                    │ abstract to program officer;│
                    │ discuss suitable study │
                    │ section             │
                    └─────────────────────┘
                              │
                              ▼
                    ┌─────────────────────┐
                    │ Prepare your application;│
                    │ refer frequently to Criteria│
                    │ for Rating of NIH Grant │
                    │ Applications, page 167 │
                    └─────────────────────┘
                              │
                              ▼
                    ┌─────────────────────┐
                    │ In your cover letter,│
                    │ suggest a study section and│
                    │ I/C; mention supporting │
                    │ program officer     │
                    └─────────────────────┘
```

I/Cs: NIH Institutes and Centers

Figure 9.4. The application: From submission through funding decision

Submit your application on time; follow instructions carefully

Review confirmation of receipt/assignment notification letter for accuracy and concerns

Review the summary statement

If revision and resubmission are recommended, consult colleagues at your institution and the program officer for guidance

Address all critical comments thoroughly and resubmit your application

If notified that application is in funding range, get IRB and IACUC approvals if not obtained before

If score, percentile ranking, and recommendations are positive, do nothing (but celebrate)

Learn from the summary statement and program officer; write a stronger application next time

If appropriate, consult the program officer about challenging a review you think is flawed

Receive notice of final funding decision

Application is funded: Begin your research

Application isn't funded: Consult your program officer for guidance and either revise or apply what you've learned to a new concept

IACUC: Institutional Animal Care and Use Committee
IRB: Institutional Review Board

> *Your NIH R01 history is a form of peer review at the national level and is weighed heavily in decisions about promotion and tenure.*
>
> —Suzanne Pfeffer, Stanford University School of Medicine

Reviewers will look for your track record in the field, so, if necessary, create one by conducting some preliminary work and presenting the results in your grant application.

Find a home for your application at NIH. In many cases the appropriate I/C and program officer for your research might be your mentor's. On the other hand, it may take legwork to find the I/C most likely to be interested in your idea. An experienced NIH program officer suggests that beginning scientists should

◆ Check the NIH Guide to Grants and Contracts (*http://grants.nih.gov/grants/guide/index.html*) for relevant and recent PAs and RFAs.

◆ Check the NIH CRISP (Computer Retrieval of Information on Scientific Projects) database (*http://crisp.cit.nih.gov*) for projects like yours that have been funded. The two letters in the grant number tell you which I/C funded the project.

◆ Conduct a literature search to see what has already been done in your area. (This can help you address the innovation aspect of evaluation criteria and, if appropriate, revise your study design or methods accordingly.)

Once you've narrowed the list of potential I/Cs, go to the Web site of each I/C to learn what areas they are currently interested in and are funding. (The NIH Web site lists all its I/Cs and offices at *http://www.nih.gov/icd.*) I/C Web sites commonly describe scientific areas of interest as well as identify the staff members who are responsible for each program area and maintain a portfolio of grants in that area.

The I/C program officer is the best person to help you decide what type of grant to apply for and which study section may be most appropriate. The program officer whose area of responsibility is most appropriate to your research also can be your best advocate and adviser at NIH throughout the application process. The program officer will not evaluate the quality of the research idea or the science. That job is left to your institutional colleagues and the study section.

Before you call this key person, be sure to have an abstract of your research project ready (see box "Tips on Writing an Abstract" on page 165). The program officer will probably ask for a copy; if not, you can offer to send one.

Review by more than one I/C. Remember, you can ask for assignment to a second I/C if you've had encouragement from another program officer or think that your application fits within another I/C's scientific areas of interest. Your application can be funded by only one I/C, but more than one advisory council can review it to broaden your chance of funding. In such cases, the application will be assigned a primary and a secondary I/C. The secondary I/C can consider it for funding only if the primary I/C opts to relinquish first right of funding.

Despite your homework on finding the appropriate I/C, the first program officer you contact may not consider your proposal appropriate for funding by that I/C. In such cases, the program officer will likely suggest a more suitable I/C and program officer.

Tips on Writing an Abstract

The abstract should convey the big picture—the general hypothesis and aims, the methodological approach, and the significance of the research. It should also include key words, which the referral officer at NIH will use to assign your application to the right study section, whether or not you request a particular review group. Try to avoid technical jargon, and write the abstract in language an educated layperson can understand.

Getting Assigned to the Right Study Section

The most important thing you can do to bolster your chance of funding is to have your application assigned to the right study section. Read the study section descriptions and rosters before finishing and submitting your application. Remember that key words in the title, the abstract, and the specific aims will be used to direct your application to a suitable study section.

If you submit a cover letter, it should contain an informed request for assignment to a specific study section and a brief explanation of why you think it's best suited for your application as you have determined through your own research and your discussion with the program officer. Include the name of the program officer who supports this request. CSR staff members will consider your suggestion for a study section; if your suggestion is logical, it is likely they will honor it. You can also recommend the type of expertise needed to evaluate your application, but you should not provide specific names of potential reviewers.

After you have been notified about the study section to which your application has been assigned, check the roster to make sure the expertise you consider essential to a fair and thorough evaluation of your application is still represented. If someone who you regard as an important interpreter of your research plan has dropped off the roster, you can request that expertise be added. These requests are generally taken seriously and responded to, and appropriate expertise is provided onsite or through an outside review by phone or mail. Similarly, if someone has joined the study section and you think for some reason that this person will not provide a fair review, you can request that this person not review your grant. Be aware, however, that during the study section meeting, the person you are excluding will be informed that you made this request.

Preparing Your Application

First, be sure you're using the most current application form. (The Web site *http://grants.nih.gov/grants/forms.htm* has the most current version of the PHS 398 Grant Application Kit.) Second, follow a simple mantra: Start early, write, read, rest, re-read, revise.

In your application, you should address the following questions, keeping in mind the information given under "Criteria for Rating of NIH Grant Applications," page 167):

◆ What do you want to do?

◆ Why is it important?

◆ Why do you think you can do it?

◆ Has this area been studied before (and if so, what has been done)?

◆ What approaches will you use, and why?

◆ Why do you think it's feasible?

◆ What will you do if your initial approach doesn't work as planned?

◆ What resources and expertise are available to you from your institution?

You should keep the following suggestions in mind as you prepare your application:

◆ Read and follow instructions, paying close attention to budget requirements and eligibility criteria (see "A Bit About Budgets," page 168).

◆ Prepare your application with care, and use spell check. No matter how strong the science, typos and grammatical errors leave a poor impression.

◆ Don't try to evade the page limit by using small type or narrow margins. You could delay your application if you disregard NIH's formatting requirements. Don't feel you must write up to the full page limit; you get points for strength, not length.

◆ Quantify whenever possible.

◆ Edit. Try to keep your specific aims to two or three sentences each. Remember that reviewers have dozens of applications to evaluate.

◆ Use language and formatting to create signposts for overworked reviewers, for example:

> The *long-term* objectives of this project are…
> The *general strategy* of the proposed research is to…
> The *specific aims* of the present study are to…
> *Four goals* are envisioned: …
> In these experiments, molecular genetic, biochemical, and structural approaches will be used to…

Reviewers Focus on the Four Cs

Clarity. Cross-reference current literature in laying out your premises.

Content. Organize your ideas around associated aims linked to your central hypothesis. (The mission statement of each I/C sets forth its areas of emphasis.)

Coherence of concepts. Present a coherent set of ideas predicated on previous work.

Cutting edge. Be ready to take legitimate risks, preferably based on preliminary data, to move the science forward. NIH rates grant applications on innovation (see "Criteria for Rating of NIH Grant Applications" on this page).

◆ Don't put anything that is critical for reviewers to read, such as key graphics, in an appendix because reviewers are not required to read appendixes.

◆ Include clear tables, figures, and diagrams (along with legends) in the text.

◆ Conduct a thorough literature search and cite all relevant literature (omissions here are often a source of criticism). Be sure to discuss your work in the context of these published results.

◆ Provide preliminary data whenever they exist.

Preliminary data. NIH understands that beginning investigators may not have much opportunity to acquire preliminary data. The NIH Guide to Grants and Contracts (*http://grants.nih.gov/grants/guide/index.html*) often announces programs (e.g., R03 and R21) that are specifically designed to allow new investigators to obtain preliminary data.

Criteria for rating of NIH grant applications. Here are some questions that reviewers will ask about your proposal:

◆ *Significance:* Does it address an important problem? Will it advance scientific knowledge? Will it affect concepts or methods in this field?

◆ *Approach:* Are the experimental design and methods appropriate to the aims? Does it acknowledge problem areas and consider alternative tactics (in other words, is there a thoughtful backup plan)?

◆ *Innovation:* Does it employ novel concepts, approaches, or methods? Does it challenge existing paradigms or develop new methodologies?

◆ *Investigator:* Is the investigator appropriately trained to carry out the proposed work? Is the work appropriate to the experience of the principal investigator and collaborators?

◆ *Environment:* Does the institutional environment contribute to the probability of success? Is there evidence of institutional support?

Question: How do I distinguish myself from my mentor if I want to continue in the same research area?

Answer: Get a letter from your mentor explaining that he or she is pleased to know that you will be continuing to work on project X, which he or she will not pursue. Have this discussion with your mentor before you start to write the grant application.

Remember, every yes answer strengthens your application. Every no answer represents an area of potential vulnerability during scientific review. For a detailed description of these criteria, see the PHS 398 application instructions at *http://grants.nih.gov/grants/grants_tips.htm*. In addition, guidelines for reviewers for grants from new investigators can be found at *http://www.csr.nih.gov/guidelines/newinvestigator.htm.*

A BIT ABOUT BUDGETS

This section does not discuss how to draw up a budget for your grant application. Most institutions have a central grants office with experienced staff who can devise budgets suitable to the scope of the research proposed and in keeping with your institution's policies. Take advantage of that expertise.

However, this section does provide an overview of six budget-related topics. The first, direct costs versus indirect costs, can be the source of misunderstanding between faculty and administration at academic institutions. The next, modular grants, concerns the initial budget request that is now part of many NIH grant applications. Budget justification, administrative budget supplement, and competing budget supplement are relevant to later requests to supplement the initial award amount. The last topic concerns equipment costs.

Direct Costs Versus Indirect Costs

Direct costs comprise those expenses that are directly related to conducting a research project. They include salaries, employee benefits, equipment and scientific instruments, consumable supplies such as printer paper and pipettes, reagents, laboratory computers, and postage. Indirect costs (informally termed "overhead") comprise the expenses that are paid to your institution by the funding organization to support your research but that can't easily be charged directly to a specific grant. These include administration, utilities, computer infrastructure, building maintenance, security, and custodial services. These costs can be from 10 percent to 80 percent of the total direct costs of a research grant. Generally, an institution's administrators negotiate indirect costs, on behalf of the investigator, with the funding organizations (such as NIH or the National Science Foundation) that allow these costs. The organization then provides funds for indirect costs to the institution, along with funds to cover direct costs charged to the research grants. In general, beginning investigators need not be concerned about indirect costs. However, you should be aware that a significant part of the budget for a large funding agency may include indirect costs; the more paid to institutions for indirect costs, the less available for direct costs for investigators and their research projects.

Modular Grants

To simplify the budgeting process, research budgets are now requested in units, or "modules," of $25,000. This applies to all investigator-initiated grants (R01, R03, R15, and R21) with direct costs of up to $250,000 per year over the period of the award. All salary, fringe benefits, and inflation increases must be built into the modular framework. The number of modules can differ from year to year. For example, acquisition of equipment can make first-year costs higher than those for subsequent years. Request what you need, but be sure to justify that amount. Budget cuts are also modular. R01s over $250,000 per year and P01 grants are nonmodular.

Budget Justification

The budget justification is a categorical description of the proposed costs. Generally, it explains staffing and supply/service consumption patterns, the methods used to estimate/calculate these items, and other details such as lists of items that make up the total costs for a category. The budget justification should address each of the major cost categories, such as

◆ Personnel

Number of positions and level of expertise for each position
Percent effort for each position
What will each member of the proposed research team be doing?

◆ Equipment

Why do you need this piece of equipment?
What equipment did you use to get preliminary data?
Why is the above equipment not sufficient to support R01-level effort?
(Cost sharing for new equipment is advisable.)

◆ Supplies

Categorize

◆ Explain large expenses

◆ Travel

Describe proposed meetings, travelers, and estimated cost/trip
Justify any foreign travel

◆ Other

Detailed description of animal per diem costs
Categorize other expenses

Administrative Budget Supplement

This budget request covers unforeseen expenses that arise, generally because initial budget assumptions have changed. Examples are increases in the cost of isotopes or animal care. Administrative supplements are also offered occasionally for special purposes. For example, you may be able to get an administrative supplement to pay for a minority student to work in your lab. These requests are submitted to the I/C program staff rather than to the CSR for peer review. If you have questions about the appropriateness of this type of request, ask your program officer.

Competing Budget Supplement

Competing continuation applications are designed for the principal investigator who wants to modify the scope of approved work (e.g., by adding an aim or following an exciting lead). These requests are subject to the competitive peer-review process, usually through the same study section that reviewed the initial application. If you're considering this mechanism, ask your program officer about the feasibility of getting those funds from the sponsoring I/C.

More advice on laboratory budgets can be found in the resources listed at the end of this chapter.

Equipment: What You Should Know

When planning to buy equipment, keep in mind the following:

◆ Cost sharing has many benefits. Consider arranging for your department or institution to share equipment costs.

◆ If you need new equipment to pursue your research, ask for it on your renewal application. Never request major equipment funds in the last year of the grant.

◆ Your institution owns equipment funded by your grant only after the award period ends. If you're the principal investigator and you relocate, the equipment generally goes with you.

◆ If you're in doubt about anything related to equipment, ask a grants management specialist at your institution.

You may find help with equipment costs through the Shared Instrumentation Grant Program (S10) or the Small Instrumentation Grants Program (S15) run by NIH's National Center for Research Resources. For more information about these programs, visit *http://www.ncrr.nih.gov.*

Office of Extramural Research Salary Cap Summary

October 1, 2004, through December 31, 2004: $175,700

January 1, 2005, through December 31, 2005: $180,100

January 1, 2006, through December 31, 2006: $183,500

SUBMITTING YOUR APPLICATION

Follow instructions for mailing. Applications must be received by or mailed on or before the published receipt date. It's appropriate to send a courtesy copy of your application to the I/C's program officer.

Confirmation Letter

NIH will send you a confirmation of receipt, which is also called an assignment notification letter. Review it carefully to make sure all information is correct and you have no concerns (e.g., about assignment to a study section other than the one you requested). The letter will include the following items:

◆ An application number with codes for the type of grant (such as R01), the assigned I/C, and an identifying application ID number. The two letters in the ID number denote the primary I/C to which the application has been assigned.

◆ The assigned SRG (or study section)

◆ The name of the SRA and contact information

The letter will also outline the expected timetable for review and funding decisions and explain who to contact if you have questions.

New Data

If new data become available after you have submitted the application, contact the SRA of your assigned study section. You may be allowed to submit this additional information. The SRA can tell you how much to send, what format to use, and when and where to send it.

Interpreting the Summary Statement

After the study section meeting, the SRA will draft a summary statement (see "Behind Closed Doors: Demystifying the Study Section," page 157). Usually, the summary statement is straightforward and will tell you whether your grant is likely to get funded or not, but in some cases, you may need help interpreting it. For example, if your summary statement recommends revision and resubmission, do the reviewers really want to see it again? Or have they politely refrained from stating plainly that they consider your hypothesis untenable, your expectations excessive, or your approach extremely flawed?

The program officer, who usually attends the study section meetings or enlists a colleague to do so, can help you interpret the results of the scientific review. If the program officer wasn't present, he or she can call the SRA for guidance. Your institutional mentor or grant committee can also help you evaluate the summary statement. After the national advisory council meeting, you can discuss the potential for funding or revisions with the program officer.

Occasionally, mistakes are made during the review process. If you believe that the reviewers criticized you for information that they overlooked in your application or think the review was flawed for other reasons, consult the program officer about the possibility of appealing the study section's decision. Although this action is sometimes appropriate, it's usually better to address review comments and resubmit your application. Follow the program officer's guidance on this matter.

If the reviewers thought your starting hypothesis was seriously flawed, don't waste your time revising and resubmitting the application. Instead, learn as much as you can from the summary statement and discussion with the program officer and your colleagues, reconsider your project and approach, and write a stronger application the next time.

Resubmitting Your Application

If your application is not immediately funded, remember that with an NIH funding average of 20 to 25 percent, many applications aren't funded the first time. If the program officer thinks it's worthwhile for you to revise the application, keep the following points in mind:

◆   Reviewers of amended applications get to see the summary statement from the previous reviews.

◆   Always treat review comments respectfully.

◆   Respond to all suggestions and comments, even if you don't agree with them.

◆ Be explicit about changes: Mark each section of the revised application where you have addressed reviewer critiques.

◆ Provide any additional data that are now available and update your publication list, if necessary.

◆ Resubmit the revised application by the due date. Your revised application now begins its journey through the review process all over again, along with the next batch of new submissions from other applicants.

Although your first instinct may be to request that your revised application be assigned to a different study section, you would need a compelling scientific reason for that request to be honored. Further, there's always the possibility that a different study section might find additional reasons to criticize your application.

A revised application supersedes the previous version, erasing the earlier score and pushing you back farther in line in the funding decision-making process. However, as the funding cycles progress and I/C staff have a clearer idea of what remains in their award budget for that fiscal year, they can reactivate the previous version if they find that the score on your initial application looks promising for funding (see "Review and Funding Cycles," page 159). If you submit a revised application and the program officer later tells you to withdraw it because your funding chances now look good, do so.

How many times can, or should, you revise and resubmit the same application? NIH policy is that after a second revision, you must reconsider your project and approach and submit a new application.

THE NATIONAL SCIENCE FOUNDATION

The National Science Foundation (NSF) is an independent federal agency with an annual budget of about $5.5 billion. It is the funding source for approximately 20 percent of all federally supported basic research conducted by U.S. colleges and universities. It provides funding only for nonmedical biological research: According to NSF, "…Research with disease-related goals, including work on the etiology, diagnosis or treatment of physical or mental disease, abnormality, or malfunction in human beings or animals, is normally not supported. Animal models of such conditions or the development or testing of drugs or other procedures for their treatment also are not eligible for support." Complete information may be found at *http://www.nsf.gov*. Information on funding opportunities in biology may be found at *http://www.nsf.gov/dir/index.jsp?org=BIO*.

RESOURCES

Example of a Funded R01
Annotated R01 grant application (NIAID), *http://www.niaid.nih.gov/ncn/grants/app/app.pdf*.

NIH I/Cs and Offices
General information, *http://www.nih.gov/icd*.

NIH Peer Review: Process, Forms, Guidelines
CRISP, a searchable database of federally funded biomedical research projects conducted at universities, hospitals, and other research institutions, *http://crisp.cit.nih.gov*.

Overview of peer-review process, *http://www.csr.nih.gov/review/policy.asp*.

Study section rosters, *http://www.csr.nih.gov/Committees/rosterindex.asp*.

Grant application forms, *http://grants.nih.gov/grants/forms.htm*.

Preparation instructions, *http://grants.nih.gov/grants/funding/phs398/phs398.html*.

Office of Laboratory Animal Welfare, *http://grants.nih.gov/grants/olaw/olaw.htm*.

NIH Funding Opportunities
Grants and funding opportunities, *http://grants.nih.gov/grants/index.cfm*.

Guide to grants and contracts, *http://grants.nih.gov/grants/guide/index.html.*

Grants site map, with links to other relevant sites, *http://grants.nih.gov/grants/sitemap.htm*.

Office of Extramural Research, *http://grants.nih.gov/grants/oer.htm*.

Other Sources of Funding Information
FedBizOpps, an evolving database of all federal government granting programs of more than $25,000, *http://www.fedbizopps.gov*.

GrantsNet, maintained by the American Association for the Advancement of Science, *http://www.grantsnet.org*.

Laboratory Budgets
Brown, Megan T. "Preparing and Managing Your First Lab Budget: Finance 101 for New Investigators." ScienceCareers.org (October 22, 1999), *http://sciencecareers.sciencemag.org/career_development/previous_issues/articles/0210/preparing_and_managing_your_first_lab_budget_finance_101_for_new_investigators/(parent)/158*.

Harmening, Denise M. *Laboratory Management: Principles and Processes.* Upper Saddle River, NJ: Prentice Hall, 2003.

McClure, Michael. "From Science Fair to Science Fare, Part 2: Establishing a Revenue Stream." ScienceCareers.org (February 28, 2003), *http://sciencecareers.sciencemag.org/career_development/previous_issues/articles/2240/from_science_fair_to_science_fare_part_2_establishing_a_revenue_stream/(parent)/158*.

Chapter 10

GETTING PUBLISHED AND INCREASING YOUR VISIBILITY

Your scientific success hinges on your ability to produce a body of publications that your colleagues will notice and respect and that granting agencies and your tenure committee will accept as proof of your research accomplishments. You are also, to some extent, responsible for the publication success of your postdocs and graduate students. After several years of graduate school and postdoctoral research, you should be familiar with writing scientific papers and the peer-review process for scientific publishing. This chapter provides some tips on planning for publication and some tricks of the trade to help you get your work published. It also offers some pointers for increasing your visibility in the scientific community.

A BRIEF OVERVIEW OF SCIENTIFIC PUBLISHING

This section reviews some of the basics of the publishing process.

Types of Journals

Within the broad category of peer-reviewed journals, individual journals vary in the audience they try to reach and in the scope of coverage they provide. For example, some journals—typically the top-tier journals—focus on a broad scientific audience. Others are deliberately narrower in scope, publishing research within a scientific specialty. In addition, a hierarchy exists within the world of scientific publishing. Some journals are more prestigious than others are, a situation that is dictated in part by each journal's *impact factor*—a measure of how frequently papers published in that journal are cited in other papers (see box "A Word About Impact Factors," page 176). The more prestigious the journal, the more competitive its publication process is.

Communication Formats

In scientific journals, primary research holds center stage, although significant space is often allocated to reviews and commentaries. Depending on how complete the study is, original research can be published in a variety of formats, including full-length articles, brief communications, technical comments, or even letters to the editor.

As a beginning investigator, you will need to concentrate on getting your research published as peer-reviewed, full-length articles. These are by far the priority of both tenure committees and the study sections of granting agencies. Technical comments and letters to the editor count for very little in most fields.

A well-written and useful review may be worth the investment of your time, particularly if you've been writing grants and have collected all the literature anyway; however, a review does not carry the weight of original research. Good reviews tend to get cited frequently by other scientists, which would increase your citation index (a measure of how many researchers cite your work); this sometimes makes a difference with tenure committees. However, reviews are extremely labor-intensive. To do them well, you need the breadth and depth of knowledge that generally come only with long experience and in knowing a lot of scientists working in a field who will share unpublished data with you. Writing a review that reveals your lack of expertise could be embarrassing, so be careful.

As your career progresses, you may want to consider other opportunities to express your views—in letters, comments, and discussions of scientific trends. Most readers peruse this "front matter," and contributing to it gives you quick and wide visibility. In the top-tier journals, however, front matter tends to be commissioned by the editors.

The Editors

Some journal editors are professional editors who trained as scientists but no longer work in a lab. Others are working scientists who have their own research programs but also serve for a period of time as editors. Journals such as *Cell, Science, Nature,* and *PLoS Biology* are staffed by professional editors. When talking to a professional editor about your work, be sure to take the time to highlight the general interest of your paper and explain the nuances of the science. An editor who is also a working scientist is more likely to already know these things.

A Word About Impact Factors

One of several types of data published by Thompson Scientific, the impact factor, is a measure of how frequently the "average article" in a given journal has been cited in a particular year or other time period. The impact factor, which is updated annually, is calculated by dividing the number of current-year citations by the number of citable items published in that journal during the previous two years.

Although the impact factor is often used to provide a gross approximation of the prestige of a journal, many other factors can influence a journal's impact and ranking. For example, review articles are generally cited more frequently than research articles are, because the former often serve as surrogates for earlier literature, especially in journals that discourage extensive bibliographies. The inclusion of review articles in a journal will, therefore, increase its impact factor.

Other methods for measuring citations include Google Scholar and CrossRef. The United Kingdom Serials Group is promoting the "usage factor" (*http://www.uksg.org*) and Google has developed the "Y factor" (*http://www.soe.ucsc.edu/~okram/papers/journal-status.pdf*).

PLANNING FOR PUBLICATION

Because publishing original research papers is critical to your career, this section focuses on submitting and publishing these types of papers.

Knowing When to Publish Your Research

Your tenure committee will want to see that you have published at least one paper a year in a highly ranked journal in your field as a senior author. (Some departments and institutions may expect several papers per year; make sure you discuss these expectations with your mentor.) If you have one or more postdocs who want to pursue research careers, each of them is under similar pressure to publish. To obtain a faculty position, it is usually necessary that a candidate be first author on two or more papers, at least one of which is a high-impact paper.

Research projects have a natural point where it makes sense to publish (see box "Creating an Integrated Research and Publication Plan," page 178). However, you may want to write up your results before you reach this point. If there is competition in your field and you wait to publish, you run the risk of being "scooped"; in this case, you would have to publish your research in a journal that is not as prestigious as the one you had initially envisioned. Also, if you wait to obtain complete results, you may not be able to publish the one paper a year required for tenure.

In deciding when to publish, you will have to balance several considerations, but try to resist the temptation to rush into print, if you have a choice. Remember, the quality of your publications is what matters most in the long run. A paper that is incomplete or carelessly put together is less likely to be accepted for publication and will be an inefficient use of your time. Even worse, incorrect results will damage your reputation.

> *Writing up an incomplete or flawed story is not time-effective, since writing a good or bad paper generally takes the same amount of time.*
>
> —Tom Misteli, National Cancer Institute

Choosing a Journal

Because most papers today have several authors, the choice of where to publish often involves considerable negotiations. All authors typically want to publish in the most prestigious journal that is likely to accept their paper, but views on which journal is best will differ. Negotiations will also depend on who is involved. As the principal investigator, you will want to take into consideration the suggestions of students and postdocs in your lab; however, you will generally make the final decision. Decisions about where to publish may become more complex when two or more principal investigators have coauthored a paper that involves extensive inter-laboratory collaboration.

Here are some questions that can help guide your decision:

◆   Are my results sufficiently groundbreaking, and do they have enough general appeal, to be considered by one of the top-tier scientific journals? Do I have a larger story that makes my results really exciting?

◆   Even if my results are not earth-shattering, have I taken an interdisciplinary approach, making the findings interesting to scientists in several fields and therefore appropriate for a general journal?

◆   If my results are primarily of interest to my particular scientific specialty, which journals reach the members of that specialty? Within this group, which journal or journals have included articles on my particular subject area in the past couple of years?

◆   Would any journals be particularly interested in my subject because it fits into a theme they have been pursuing? Some journals, and some editors, pursue their own special interests over time.

The top-tier journals receive far more submissions than they can publish. For example, *Nature* rejects about 95 percent of the biomedical papers it receives. Be realistic about your chances. You will lose precious time by submitting your paper to the wrong journal.

It helps to ask trusted colleagues where they think your paper should appear. If they are frequent reviewers for several journals in your field, they will have a good idea of what the standards are for each journal.

Creating an Integrated Research and Publication Plan

There is a balance to be struck between trying to produce a "dream paper," which may never get done, and sending out a set of fragmentary observations. One way to find this balance is to integrate your plans for publication into your research plans. In her book *At the Helm: A Laboratory Navigator*, Kathy Barker suggests strategies for doing this. As you decide on the long-term goals of your research and on the series of experiments or calculations you want to undertake, Barker suggests that you envision these experiments or calculations as components of a published manuscript or series of manuscripts. Think graphically; imagine how each set of results will be displayed in a figure, graph, or table. Put your ideas in writing at the outset, sketching out the hypotheses you want to pursue, the methods you intend to use, and the results you hope to get. By integrating research planning, the development of displays of your data, and interpretive writing, you force yourself to focus your energy and you move your project forward. The questions you generate as you analyze and write up the results of each experiment should suggest additional clarifying experiments, which you should also express graphically. As you write, you will uncover gaps in information and shaky conclusions. Eventually, you should be able to decide that you have a set of results that warrants publication.

Making Your Pitch

To make sure you write your paper for the right journal, you may want to submit an initial query to your target journal to gauge its interest in your work. Most journals have guidelines for submitting so-called presubmission inquiries; check journal Web sites for this information. If the journal does not provide guidelines, send an e-mail to one of the editors. (Try to find out the name of the editor who handles papers in your area.)

A presubmission inquiry usually includes the following:

◆   An abstract stating the purpose of the project, methods, and main findings and conclusions. This abstract can be slightly longer than the abstract of a typical research paper and may include citations of relevant journal literature. Make sure that the abstract is clear to nonspecialists and that they will be able to understand what the scientific advance is.

◆   A cover letter briefly describing what questions led you to your research project, what you did, why you think your findings or methodology is significant, how your findings advance the field, and why they are of special interest to that journal's readers. Limit the cover letter to no more than 500 words.

Presubmission inquiries are typically considered within a few days; when that time has elapsed, follow up with a telephone call or e-mail. If you contact an editor by phone, use the opportunity to make your pitch. Be sure to allude to the larger context of your research—the big picture that makes your particular effort meaningful.

You can expect a reply of either "we're not interested" or "send the full manuscript." A positive response to a presubmission inquiry is *not* a guarantee that the manuscript will be sent out for formal peer review. The editor will want to see the actual paper before making that decision.

GETTING YOUR PAPER PUBLISHED

Writing Your Paper

Once you have decided where you want to submit your manuscript, review the journal's editorial guidelines (available from the journal's Web site or directly from the editor) and follow them carefully.

The main consideration when writing a paper is to clearly describe your most important findings and their impact in your field. Don't let your manuscript look like a compilation of lab data; make sure the reader can understand how you have advanced the field of research. But don't overdo it—claiming that your work is more important than it really is earns little more than contempt from reviewers.

Assign the task of writing the first draft of the paper to the student or postdoc who will be first author. Encourage that person to prepare the figures, tables, and legends first, because a scientific paper is best written with the final form of the

data in front of the writer. Then work with the author to get the paper into shape. Although this may not be the most efficient way to write a paper, it is important for people in your lab to get experience and feedback on writing papers.

Once you have a good draft, send it to colleagues in your field and in your department for review. Have it proofread by someone in your lab with access to your data and the documents you have cited. The last thing you want to do is to appear careless; doing so will raise suspicions about the quality of all your work. It is also a good idea to give the paper to someone outside your field to see whether they understand its importance.

Three particularly difficult parts to write are the title, abstract, and cover letter.

Title and abstract. Create these two elements after the manuscript is complete. The title should summarize the take-home message of your paper. The abstract should briefly summarize the paper and should stand on its own. Describe the experimental question, the methods, the main results, and the conclusion. Unless the main point of the paper is a new technique, methods should be limited to a sentence or a few words. Keep in mind that the abstract will announce the existence of your work to people who may not have time to read your paper. If the abstract attracts their attention, they could be induced to read your article, rather than passing on to the next abstract. Also note that your title and abstract will be used as the basic tools for the retrieval of your paper from electronic and paper libraries.

Cover letter. The cover letter should explain why the paper is significant and why you think it is appropriate for the journal to which you are submitting it. The letter should cite a major question in your field and describe how your work helps answer it. You may want to cite other papers the journal has published in this field or provide other reasons why the journal's readership would find your work of interest. The letter of introduction is the place to mention whether there is competition in the field that could lead to your being "scooped," as well as to include a list of colleagues who have reviewed the paper and any information necessary to ensure a fair review process. Most journals will give you an opportunity to suggest people who are qualified to comment on your work and to exclude one or two particular individuals who may be competitors and should not be reading about your work before it is published. Be sure to take this opportunity.

Many books and articles that explain how to write scientific papers are available in print and online. (Some of these are listed under "Resources" at the end of this chapter.)

Submitting Your Paper

Most major journals require that manuscripts are submitted electronically through the journal's Web site. Each journal has its own requirements, such as preferred file formats for text and figures and the procedures for uploading files. Consult the journal's Web site for specific instructions and be sure to follow them.

Regardless of whether they receive a paper manuscript or an electronic version, most journal editors will let you know that they have received your manuscript and how long you can expect the review process to be.

Submitting Image Files

Today, most images are obtained digitally and programs like Adobe Photoshop make it very simple to modify their quality. But sometimes by adjusting an image you can make inappropriate changes to your data, which could be classified as scientific misconduct. Since 2002, the *Journal of Cell Biology* has been doing simple, routine checks of every image of all accepted manuscripts to look for signs of manipulation. This step has in some cases caused editors to withdraw the acceptance of a paper and in a few cases to notify relevant institutions. Other prominent journals may take similar steps.

Here is what the *Journal of Cell Biology* says constitutes inappropriate manipulation of images: "No specific feature within an image may be enhanced, obscured, moved, removed, or introduced. The grouping of images from different parts of the same gel, or from different gels, fields, or exposures must be made explicit by the arrangement of the figure (e.g., using dividing lines) and in the text of the figure legend. Adjustments of brightness, contrast, or color balance are acceptable if they are applied to the whole image and as long as they do not obscure or eliminate any information present in the original. Nonlinear adjustments (e.g., changes to gamma settings) must be disclosed in the figure legend."

For more information, see Rossner, M., and K. M. Yamada "What's in a Picture? The Temptation of Image Manipulation." *J. Cell Biol.* 166:11–15, 2004.

Navigating the Review Process

The reviewers of your paper will be chosen by the journal's editor, who will take into account any names you have suggested, his or her own knowledge of the field, and a literature search.

Receiving the reviewers' comments. A paper is rarely accepted after the first round of review. When you receive the editorial decision and the reviewers' comments, you will have to decide how to proceed. Sometimes the editors will indicate they would like to publish your work, provided that you make a few minor revisions or do a few additional experiments. In other cases, the editors will say that the work is potentially interesting but too preliminary or that it has significant flaws that preclude its publication. Another possibility is that the reviewers will advise the editors not to publish the work even if it is revised, because it is either not sufficiently novel or it does not fit the scope of the journal. Most editors are happy to talk to you by telephone to help you assess whether you should revise and resubmit your paper or try another journal. In any event, it is important to remain unemotional during such conversations.

Responding to reviews. Do not react defensively. Focus instead on the substance of each editorial comment. Value good advice wherever you find it. Read the reviews carefully and communicate your responses in writing to the editor. It is a

good idea not to respond as soon as you hear from the editor. Let a couple of days go by. A hastily written and emotional response will hurt your chances for resubmission.

If the reviews include a request for additional information that will require a few more experiments, carry them out and send your response to the editor. You can make the process easier by repeating each comment, stating your response, and indicating explicitly where in your paper you are making a recommended change. If the main problem is that the manuscript does not convey the importance of the work, you may want to rewrite it and add more data. You might want to check with the editor first to make sure this is an appropriate course of action.

In the end, you will have to do a cost-benefit analysis. If you believe that satisfying all the reviewers' concerns would bog down your research program in unnecessary experiments, you may have no choice but to take your paper elsewhere.

If you think a requested additional experiment is unreasonable, write a rebuttal letter explaining why the experiment cannot be done or why it will not help strengthen the conclusions of your paper. You may discuss your concerns with the editor, before working on a revised manuscript. For example, you should ask, "If I do revisions A and B, but instead of doing experiment C, I do D, will you still consider a revised manuscript?" Remember that you are the person best acquainted with the details of your work and the limitations of your research tools. If you think a referee's comments are completely off the mark, write a rebuttal letter explaining your concerns. If all three referees, or even two out of three, had serious misgivings, it may be difficult to convince the editor that the referees missed the point.

Regardless of how you proceed, keep your emotions in check. You should never demean the reviewers. The reality is that reviewers, especially those who manage their own laboratories, sometimes work under unrealistic time pressures. Occasionally, the reviewer selected may not have the expertise to judge a paper competently. Whatever the case, do not question a reviewer's expertise. If you think a reviewer missed an important point, politely tell your editor, who has the option of identifying additional reviewers for your paper if doing so seems warranted.

If You Are Asked to Review a Paper

As your relationships with journal editors develop, you may be asked to review manuscripts submitted by other scientists. Take the task seriously. Do the reviews thoroughly and promptly. If you don't have time or don't think you have the right expertise, let the editors know right away. They will not hold this against you. A late or weak review, however, could hurt your reputation with the editors. The benefits of serving as a reviewer are potentially great. Not only will you learn about others' research, you will improve your own critical skills and confirm your standing as a knowledgeable scientist in the eyes of the editors. Your own future papers will be taken more seriously if you do good reviews. You will be asked not to reveal the contents of any article reviewed and be reminded that you should not use your knowledge of the prepublished results to further your own research. Take this admonition seriously—it is essential that you respect the confidentiality of the review process. If you have a conflict of interest that precludes you from reviewing an article (e.g., you are directly competing with the author of the article you are reviewing or the author is one of your former postdocs), stop reading the paper and let the editors know immediately. They will not be pleased if they find out about a conflict of interest after you have reviewed the paper.

Submitting your paper to another journal. If you are advised that your paper isn't appropriate for the journal to which you have initially submitted it (e.g., it is not sufficiently novel or does not have the right focus), the best course is usually to select another journal. In some cases, you may not want to inform editors of the second journal that the manuscript was submitted elsewhere and rejected—it might prejudice the process. For example, if your paper was rejected by *Nature* and you resubmit it to *Science* (or vice versa), don't let the editors of the second journal know. These journals compete for the best papers and don't want to publish each other's rejections. If, however, your paper was reviewed by *Nature* or *Science* and the reviews were generally positive but the editor did not feel the paper had a sufficiently high impact value for a top-tier journal, you may be able to use the reviewers' comments as leverage for your next submission to a second-tier journal. Ask the first journal's editor to support the resubmission, and tell the second editor that your paper has already been reviewed. The second review process may be expedited.

Regardless of your course of action, never send a rejected manuscript without changes to a second journal. If, as is likely, the same reviewers receive it a second time, they will be annoyed to see that you have completely ignored their comments.

INCREASING YOUR VISIBILITY

Your patience and persistence have paid off, and your article has been accepted by a good journal. Now you can use your newly minted publication as a tool in a legitimate effort at self-promotion. You want to become known to your scientific colleagues nationwide. Here are some things you can do:

◆   Announce the publication on your personal Web site and in e-mail correspondence with your friends. Consider making it available in PDF format.

◆   Give a workshop or a brown-bag presentation at your own institution on the research described in your article and your future research plans. Doing so is relatively easy and is good practice.

◆   Call your friends at universities around the country and offer to give a talk on your research at their institutions or at conferences they are organizing. However, don't invite yourself to a meeting by writing to the organizers if you do not know them. You might come across as arrogant and put people in the awkward position of having to turn you down.

◆   Once you have an invitation, take it seriously. Prepare and rehearse your talk.

◆   Consider going public. Contact your university public relations office for help in contacting the media. It is in the university's interest to have the good work of its scientists publicized.

◆   If your research was supported by an outside funder, let the appropriate staff at the funding organization know about the publication as soon as possible.

◆ If a reporter contacts you, make an effort to speak with him or her. Your university's public relations office can help you prepare for the interview. Keep in mind that many reporters are not scientists and you will need to give them sufficient background for them to understand the importance of your work. If possible, ask reporters to give you a copy of the story before it is published so that you can check for accuracy (note, however, that many reporters work on tight deadlines and will not be able to accommodate the request).

Getting your work published and promoting your publications are essential, interrelated tasks of scientific communication. So think "big picture" and "long term" when working on your publications, presentations, and other efforts to bring your work to the attention of others in your field.

> *I learned early on that if you want to be promoted, you need to get a national reputation. This means that you have to be invited to give talks at universities around the country and at national conferences. The people listening to you might be the ones recommending you for promotion, they might be sitting on an NIH study section when your grant comes up for review, or they might be potential collaborators. Or they might be graduate students who would consider coming to your lab as postdocs. So how do you get these invitations when you're just starting out? Well, you can't be shy. You have friends all over the country who are also young faculty and carrying out work that would be of interest to your department colleagues. Call them up and make a deal: "I'll invite you if you'll invite me."*
>
> —Thomas Cech, HHMI

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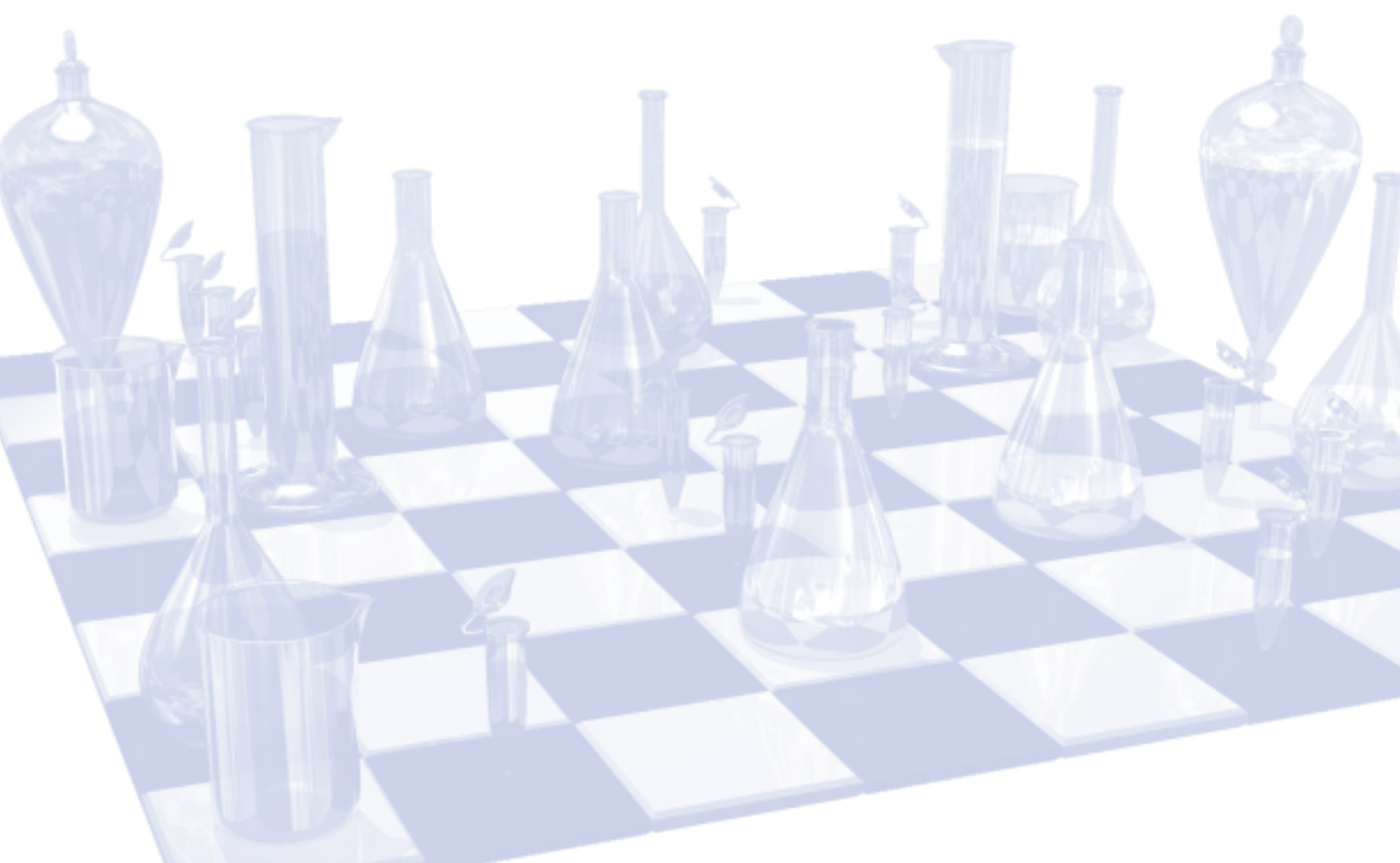
Chapter 11

UNDERSTANDING
TECHNOLOGY TRANSFER

Two decades of explosive growth in biomedical science have quietly revolution-ized the role of academic investigators in the commercialization of research results. Patent applications for promising discoveries, once the near-exclusive domain of industry, are now filed routinely by research universities. Through the process known as technology transfer, these patents are licensed to companies for develop-ment into marketable products or services.

The technology transfer guidelines at your institution will be based, at least in part, on federal and state laws, regulations, and guidance. This chapter provides an overview of the technology transfer information most important to academic sci-entists. The information should be viewed as a supplement to the information in your institution's faculty handbook and its intellectual property policies.

The chapter reviews the role of the university's technology transfer office (TTO) and covers the ways in which a university's intellectual property (IP) is protected, the process for bringing an invention to market, and diverse types of legal agree-ments. Conflicts of commitment and interest are also discussed.

UNIVERSITY TECHNOLOGY
TRANSFER OFFICES

In 1980, the U.S. Congress passed the Bayh-Dole Act to jump-start the transfer of inventions from federally funded academic laboratories to the public. As a result, today most academic research institutions have TTOs that, with the help of the inventor, evaluate an invention for potential use and marketability and handle the forms, filings, negotiations, and follow-up of technology transfer. Most universities' TTOs follow the provisions of the Bayh-Dole Act, regardless of whether the research is federally funded. This means that if you make a discovery with potential commercial value, your university will own and control the IP, but you will get a percentage of any resulting licensing income, including royalties.

Soon after taking your post at your new institution, you should meet with the TTO staff. They can tell you about what they do and how they can help you.

THE TECHNOLOGY TRANSFER PROCESS

It Starts with an Invention

For a scientist, most technology transfer begins with an invention: a new and useful process, a machine, an article of manufacture, composition of matter, or any related improvement to these. The invention itself has two steps: conception and reduction to practice. Reduction to practice is further subclassified into two types:

◆ Constructive reduction to practice involves filing a patent application even though an invention isn't yet physically reduced to practice or "made." The information in the application should make it possible for a person of ordinary skill in the art to make and use the invention without undue research or experimentation.

◆ Actual reduction to practice requires a working model demonstrating that the invention will work as intended.

Moving from Invention to License

The journey from invention to license can be frustratingly long and very expensive. The following are typical steps:

◆ *Discussion:* The inventor informally discusses the invention with the institution's TTO. These discussions may help the inventor decide whether to proceed with filing an invention disclosure. In some cases, further work on the invention may be advisable before proceeding.

◆ *Disclosure:* The inventor reports the invention to the TTO using the institution's standard disclosure form.

◆ *Evaluation:* The TTO assesses the invention for patentability and commercial potential.

◆ *Filing and commercialization decisions:* The TTO may ask the inventor to do further work on the invention before proceeding, may file a patent application if the invention has commercial potential and appears to be patentable, or may decide to market the invention without filing for patent protection. If the TTO is not excited by commercialization prospects, it may "waive title," in which case ownership rights may be released to the inventor. Some universities waive title only on certain conditions—for example, an inventor may be asked to reimburse patent costs or pay a percentage of any income from the invention or both.

◆ *Marketing:* The TTO will contact potential licensees.

◆ *Licensing:* The TTO will negotiate and manage licenses to companies.

At the end of this process, approximately 30 percent of inventions reported to the TTO (disclosure) will be licensed.

Should I File an Invention Disclosure?

Deciding whether to file a disclosure with the TTO to report a discovery made in your lab may not be a clear-cut matter. You may wish to discuss it with TTO staff before making a decision. Some of the factors that might encourage you to file include the following:

◆ The invention could lead to a useful diagnostic or pharmaceutical, and patent protection would be necessary to convince a company to incur the costs of development and clinical trials.

◆ You and your university, department, and colleagues could profit from a patent both financially and in terms of enhanced reputation.

◆ If you pass on the opportunity to file a disclosure, and go ahead with public disclosure of your work, it may not be possible to obtain patent protection later on.

Before filing a disclosure, you should also be aware of the following considerations:

◆ Dealing with the TTO, patent attorneys, and eventually, licensees, can be very time-consuming.

◆ Filing for patent protection can delay publication; you will want assurances from the TTO that the delay will be minimal (often 30–60 days is reasonable).

◆ If you can't identify a specific use and potential licensees, it may be unrealistic to expect that the TTO will be able to solve this problem.

◆ Be careful with patents on research tools; you will want your invention to be made broadly available, not restricted for the use of a few.

THE LEGAL TERMS AND AGREEMENTS

This discussion is an overview of some of the common terms and legal agreements used in connection with technology transfer. For more information and project-specific assistance, consult your institution's TTO.

Patents

The U.S. Patent and Trademark Office (USPTO) grants three types of patents:

◆ Utility patents (20 years) may be granted to anyone who invents or discovers any new and useful process, machine, article of manufacture, composition of matter, or any new and useful improvement to these.

◆ Design patents (14 years) may be granted to anyone who invents a new, original, and ornamental design for an article of manufacture.

◆ Plant patents (17 years) may be granted to anyone who invents or discovers and asexually reproduces any distinct and new variety of plant.

Most patents produced by academic researchers fall into the utility category.

> *Educate yourself about what constitutes public disclosure. Talking to a grad student doesn't, a faculty lecture comes close, and a presentation in a public forum may cost you the patent rights.*
>
> —Martha Connolly, Maryland Technology
>   Enterprise Institute

What does a patent do? A patent gives the owner or an exclusive licensee the right to exclude others from making, using, or selling the patented invention for a specific period that begins with issuance of the patent. The patent provides protection within the country where the patent is granted. For U.S. patent protection, an application may be filed up to one year after public disclosure of the invention, but patent rights outside the United States can't be obtained if public disclosure occurs before a patent application is filed.

Question: Are the public disclosure rules the same for foreign patent rights?

Answer: No. If your invention is publicly disclosed before you file a patent application, you lose foreign rights. If you file a U.S. application before the first public disclosure, you have one year from that filing date to file foreign patent applications. A Patent Cooperation Treaty application preserves the right to file in selected foreign countries for 18 months after the one-year period.

Researchers must have a clear understanding of what constitutes public disclosure. If something you say or write allows someone else to practice your invention before a patent application is filed, you may have created a bar to filing patents on your invention outside of the United States. Before discussing your discovery in any forum that could be considered public, you may wish to consult your TTO about the proposed disclosure.

What is—and is not—patentable? To be patentable, an invention must be useful, novel, and "nonobvious" to someone of ordinary skill in the art. If you think you have a discovery that meets these criteria, the best approach may be to go directly to your TTO and let the experts take charge from there.

You may want to conduct a "patentability search" of key words at *http://www.uspto.gov* to screen for similar inventions in the files of patent applications. You can do this yourself, without the aid of a patent professional.

Certain forms of unpatented IP may be licensed to companies by the TTO for commercial use. These kinds of IP include the following:

◆   *Tangible property:* This can be licensed for compensation but without patent protection; others are not precluded from independently developing the same materials. Examples are cloned DNA, viral vectors, cell lines, seeds, tissues, and organisms.

◆ *Know-how:* This can be licensed in some circumstances, usually nonexclusively in conjunction with a patent license. Examples are techniques, experimental systems, and special knowledge.

◆ *Copyrighted works:* Although copyright in scholarly works normally rests with the authors, copyright in other written works may be claimed by the university. Examples are formulas, algorithms, and software, including source code.

In contrast to industry, universities almost never maintain trade secrets, which are antithetical to the knowledge-expanding culture of an educational institution.

Who Owns Inventions at a University?

As a condition of employment, U.S. universities require faculty and staff to assign invention rights to the university. A common key phrase in university IP policies is "use of university funds or facilities" in conception or reduction to practice of inventions or development of materials, which extends the institution's ownership to IP of graduate students and guest researchers. In other words, the university owns inventions made by university personnel and may have rights in inventions made by others using university funds or resources.

The patent application. When the TTO is confident that your invention meets the criteria for being patented and has commercial potential, it's time to prepare a patent application. Like most legal documents, a patent application is best prepared by a specialist—a patent attorney or agent. Universities normally hire patent law firms to prosecute patent applications.

The patent attorney is likely to need input both from the inventor(s) and the TTO in order to prepare a patent application. You can expect to speak with the patent attorney several times over the course of the patent process. You will probably also be asked to review draft documents. The major elements of a patent application are the abstract, background/introduction, specification (how to practice), and claims.

In preparing the patent application, the patent attorney will need to make a determination of who should be named as inventors. It is important that this determination be accurate, because a patent may be invalid if the named inventors are not correct (either because an individual who did not make an inventive contribution is named or because an individual who made an inventive contribution is not named). The inventors may differ from the authors of the paper that describes the invention. For example, a postdoc who joined the project after the inventive steps had occurred and then provided supporting data might be a coauthor but not an inventor. Normally, only the named inventors share royalties under institutional policies.

Question: How much does it cost to get a patent?

Answer: Costs vary widely depending on factors such as the patent attorney's time spent and hourly rate, what is being patented, the number of claims in the application, the number of (and reasons for) USPTO rejections, and whether foreign filings are pursued. Preparation costs can run between $5,000 and $20,000 and up, and filing fees and possible prosecution cost between $3,000 and $5,000 and up (sometimes much more). The university pays the fees, but in almost all cases, the first income from the invention is earmarked for reimbursement of these costs. Only then does the income-sharing formula for the inventors kick in.

What happens to the patent application? From the time the application is filed, the USPTO usually takes 12 to 18 months to complete its examination and issue an "Office Action."

The first Office Action is generally a rejection. The applicant is then required to narrow patent claims and justify the novelty or nonobviousness of the invention in the light of prior art identified by the USPTO. Subsequent Office Actions often result in issuance of a patent, but this process takes an average of about three years.

An alternative is a provisional patent application, a streamlined version that can be filed without some of the time-consuming formalities of the standard form. The USPTO doesn't examine this type of application, a patent can't be issued directly from it, and it expires automatically one year after its filing. During that year, the university can file a regular patent application. So what's the point? This option has at least three benefits:

◆ Temporary filing protection can be secured for your invention for less money (less time for an attorney and a filing fee of only $100 for a small entity or a university).

◆ If filed before a public disclosure, a provisional application preserves the right to file for foreign patent protection.

◆ The one-year term of a provisional application doesn't count toward the 20-year (or other) patent term.

Many applications filed by universities are provisional, even if the application is extremely thorough. The reason: This option buys valuable time. The technology is usually at an early stage of development. A year later, the TTO can file a regular application that includes not only the invention described in the provisional patent application but additional results developed in the interim, which may result in approval of broader claims.

Technology Transfer and Faculty Recruitment

Increasingly, TTO staff are part of the university recruiting team. When faculty candidates compare employment offers, many often consider the university's commercialization record and policies regarding income sharing.

Commercialization record. Licensing and commercialization success can be strong selling points, along with the TTO's track record in crafting advantageous terms.

Income sharing. Formulas differ for distributing IP-related royalty and equity income, but a common distribution is 40 percent as taxable income to the inventors (split if there are multiple inventors), 40 percent to the inventors' departments for education and research, and 20 percent to the university for management of the invention and support of technology transfer efforts. However, some universities give the inventors as much as 50 percent of net licensing income, and others give the inventors as little as 20 percent.

Despite its conditional nature, a provisional application shouldn't be a sloppy filing that the TTO plans to fix during the following year. It should be prepared by a patent attorney or agent and held to the same standards as the work that led you to this point. In addition, be aware that in some cases in which a provisional patent is filed, TTO staff may not yet have done a thorough search for competing or similar patents. You should find out whether such searches have been conducted and make sure a patent attorney examines the results.

Licensing Agreements

In technology transfer terms, a license is a legal contract that allows a company to make, use, and/or sell a university's invention. Through a licensing agreement, someone agrees to pay for the use of IP that someone else (in this case, the university) owns—under strictly defined terms and conditions that are specific to each license—but the university maintains its ownership rights to the IP. In other words, a license allows people (or entities) to make, use, or sell something they don't own without being prosecuted. If special know-how developed by the inventors is needed to "practice" the invention, it's often included as part of the licensing agreement.

Licenses can be exclusive or nonexclusive. An exclusive license grants the right to use the invention to only one licensee. Exclusive licenses usually allow the license holder to sublicense the invention to others for a fee. These sublicenses generate "pass-through royalties" as an additional source of income to the university. A license also can be granted exclusively to one licensee for a specific application, or "field of use," maintaining the university's option to issue licenses for other fields of use.

A nonexclusive license can be granted to multiple companies. The TTO, with the inventor, will decide whether an invention is best licensed exclusively or nonexclusively. Know-how is usually licensed nonexclusively in order to preserve the inventor's right to share the know-how with other scientists informally.

Question: Do I have any say in where my invention is licensed?

Answer: Although your university has ultimate authority regarding the choice of licensee and the license terms, you will probably have some control over where your invention goes. In the licensing process, a full faculty member's preferences will likely carry more weight than a postdoc's. In some cases, a company will already have licensing rights because it provided research funding or materials. If it exercises those rights, the university may not be able to license the invention to any other company, regardless of the university's or inventor's preferences.

Your TTO will probably handle licensing arrangements for your institution, but keep in mind one point: Many companies often want all future improvements to an invention to be licensed to them. However, universities generally do not license inventions or improvements (unless very narrowly defined) that have not been made. This policy serves as a protection to you, the inventor, to keep from encumbering your future research results. You need to be aware of the tension between the interests of the university and the companies to whom inventions may be licensed.

Negotiating the Agreement

The TTO has responsibility for protecting the university's and the inventor's interests. If the inventor insists on unreasonable terms, some TTOs may be obliged to present them, damaging the negotiating process and the relationship in which all of you will be tied. So, try to refrain from inserting yourself into the negotiating process in this way. During the negotiation, however, it is necessary for you to understand what restrictions an exclusive license may impose on your ability to share data or materials with others.

Option Agreements

An option agreement is a right to negotiate a license—a document that says, "I want to and I hope I can, but I'm not ready yet." It's less complex than a license, relatively easy to negotiate, and may or may not include the financial terms of the expected future license.

Because it's of limited duration (usually 6 to 12 months), an option agreement is a useful mechanism in dealing with start-up companies and their inherent uncertainties. It gives the hopeful licensee an opportunity to secure funds and attract other resources needed for commercial development, and it gives all parties time to evaluate the technology and what each brings to the table and to establish trust.

Material Transfer Agreements

Often as a result of a publication or presentation, other researchers may request materials from your lab—generally a cell line, animal model, research reagent, genetic construct such as a plasmid or phage, or purified proteins. Some institutions require that a material transfer agreement (MTA) be signed and returned before material is sent out. Some send the MTA form with the shipment and consider delivery of the material to be implied consent, whether or not a signed MTA is ever returned. Others may be unconcerned about keeping records for outgoing material (at least when the recipient is another nonprofit institution).

Almost all MTAs for incoming materials require the signature of an authorized representative from the university. Even if an institutional signature is not required by the materials provider, university policy may call for institutional review of the terms anyway. Check with your university's TTO about who needs to approve the terms for and signs MTAs for incoming materials for your lab.

MTAs have distinct uses and caveats according to the entities involved. The following lists address three MTA scenarios: transfer of materials between academic labs, from academia to industry, and from industry to academia.

MTAs covering transfers between academic labs. These MTAs usually have relatively benign provisions. An exception is when the materials have been exclusively licensed to a company that successfully negotiated for restrictions on distribution. Work to avoid this situation because it puts your responsibilities as an author to share reagents at odds with your contractual responsibilities to a licensee. MTAs used for transfers to an academic lab typically and reasonably require that recipients of the materials do the following:

◆   Use the materials for noncommercial research purposes only.

◆   Acknowledge the providing scientist in publications.

◆ Not send materials to third parties without the provider's consent.

◆ Assume responsibility for damages caused by use of the materials by the recipient.

◆ Not use the materials in human subjects.

MTAs used for transfers from academia to industry. These MTAs usually do not permit use of the materials commercially (e.g., for sale or to make a commercial product) or in human subjects but allow use for defined internal research purposes. They may also require that recipients do the following:

◆ Share manuscripts before publication, in addition to providing proper acknowledgment in publications.

◆ Indemnify the provider for damages caused by use of the materials by the recipient.

◆ Not send the materials to third parties.

◆ Pay a fee.

MTAs used for transfers from industry to academia. These MTAs tend to be the most restrictive and difficult to negotiate. They may include the following terms:

◆ *Ownership:* Beware if the definition of materials specifies that the company will own all derivatives and modifications made by the recipient or if the MTA requires assignment of inventions to the company or provides the company with an automatic nonexclusive license to all inventions. Many institutions try to avoid granting broad "reach-through" rights in new materials or inventions developed by their faculty.

◆ *Publications:* Beware if the MTA reserves to the company the right to approve or deny publications. More reasonably, the company may require review of manuscripts 60 days or more before submission for publication, and delay of publications for 60 days or more after manuscript submission. At a minimum, most companies want a 30-day prepublication review to protect confidentiality and their investment and to consider filing for patent protection.

◆ *Reporting:* The MTA may require extensive reporting and sharing of data from the recipient.

The university's TTO will scrutinize the language of an MTA for incoming materials for restrictions like these and weigh the costs and benefits. If negotiations can't alter unacceptable MTA terms, the university may refuse to proceed. Under these circumstances, the requesting university scientist will not be able to get the materials from that provider.

SPONSORSHIP AND CONSULTATION

Through publications, presentations, and personal contacts, the work of an academic investigator might pique the interest of industry. If there's a good fit between the avenue of research and the company's strategic interests, the company may want to buy an option to commercialize the lab's research results or support some of the investigator's research. Or the company may invite the investigator to become an adviser or consultant. The typical mechanisms for doing so are described next.

Sponsored Research Agreements

When a company funds a university laboratory's research, the terms are spelled out in yet another form of legal agreement, called a sponsored research agreement, negotiated by the TTO or the university's grants and contracts office. Most sponsored research agreements will take into account the following guidelines:

◆ *Project control:* The work should be entirely under the control of the university, not directed in any way by the sponsor.

◆ *Technical representatives:* A person from the institution and the sponsoring company should be identified to serve in this capacity, establishing a researcher-to-researcher relationship. These are usually the scientists leading the research at both places.

◆ *Reporting:* Reporting requirements should be limited, and oral reporting allowed as much as possible, to minimize what can otherwise be a time-consuming burden. Sponsors usually require quarterly or semiannual reports or meetings for periodic updates on the research.

◆ *Publishing rights:* The university should ensure that the laboratory has the right to publish and present all findings. The sponsor may have the right of advance review but not the power to veto proposed publications and not the right of editorial control.

◆ *Invention rights:* The university owns inventions that arise from the sponsored research but will tell the sponsor about the inventions in confidence.

◆ *Licensing rights:* The sponsor is usually given a time-limited right to negotiate for an exclusive or nonexclusive license to inventions that arise from the research.

◆ *Discussion and collaboration:* The university researchers should have the right to discuss their work on the sponsored project with other academic scientists and to collaborate with them (as long as the other scientists are not funded by a different company).

Question: How do I find the right sponsor for my research?

Answer: Look for a strategic as well as a scientific fit, an alignment of business objectives, and a supportive alliance with management. Heed your instincts: If it doesn't feel right, chances are that it's not right.

Consulting Agreements

Faculty members are usually allowed to spend a limited amount of time on consulting outside their institutions. If you have a manual that outlines the university's consulting policies, make sure you read it and understand the policies.

Review the agreement. If your institution chooses to review consulting agreements involving employees, the appropriate office will examine your proposed agreements for conflicts of interest and other problems. If your institution does not review these agreements, consider hiring a qualified person (e.g., a contract law specialist) at your own expense to conduct a contract review because consulting may subject you to personal liability. The TTO can probably give you a referral for this purpose.

Best practices. Consulting agreements vary widely to suit the particulars of a given situation, but they should abide by some general best practices as outlined below.

Companies should engage consultants for the exchange of ideas only, not to direct or conduct research on behalf of the company. They should not use the name of a consultant or university in promotional materials unless they have written consent.

Consultants should have a limited and reasonable time commitment (e.g., a maximum number of days per year for a specific number of years). There should be a provision allowing the consultant to terminate the agreement by giving reasonable notice, and it is fair for the company to have the same right. Consultants should

Protecting the Rights of Graduate Students

Typically, industry-funded research agreements provide the industrial partner with an interest (normally licensing rights) in intellectual property that results from the funded research and include confidentiality obligations restricting the dissemination of the results.

Such provisions may raise issues when students are involved in the research. For example, a graduate student has to be able to communicate his or her thesis work in order to graduate. It is important that students are fully informed by their existing or potential supervisors of any existing or potential contractual agreements between an industry sponsor and the university or academic center that may affect their projects. It is also important that university policies relating to student participation in industry-funded projects are followed. The supervisor should have a clear understanding of what the agreements entail and how they might affect a student's ability to communicate his or her work as well as inform students of any restrictions that may affect them. During the course of the industry-funded project, graduate students working on the project must be free to present and discuss their research in university forums, such as lab meetings or graduate student seminars, and meetings of the thesis advisory committee. This may be directly in conflict with confidentiality obligations in the agreement. In some cases, it may be possible to arrange for confidentiality agreements to be signed (e.g., by the thesis advisory committee); in other cases, it may be neither possible nor consistent with university policy. As to final publication, many universities have guidelines stipulating that publication of thesis-related research may be delayed no longer than 90 days from the time a manuscript is submitted to the sponsor for review. This delay should be sufficient for the filing of a patent application and allow the industry sponsor an opportunity to request deletion of any of its proprietary information from the manuscript.

not disclose information about their laboratory research that they wouldn't normally disclose to members of the scientific community. In addition, they may assign to the company rights in inventions arising from consulting activities if such rights haven't arisen from their own research undertaken as a university employee.

Consulting agreements should acknowledge that the consultant is an employee of the university and is subject to all of its policies, including those related to IP and conflict of interest (COI). If the company requires a noncompetition clause, the consulting agreement should state that this provision doesn't apply to the consultant's relationship with the university.

CONFLICTS OF COMMITMENT AND INTEREST

Whether the lure is simply scientific inquiry or economic rewards, a career can easily run aground on conflict of commitment or interest.

Conflict of Commitment

Is your time really your own? Yes and no. As an employee, your first professional obligation is to fulfill your agreed-upon duties to your employer—the university or research institution. Faculty members should give priority to their time and goals accordingly. The "20 percent rule" is a good guideline (if consistent with your university's policies): You may take up to 20 percent of your time for outside activities that are in the interest of you and the university.

Conflict of Interest

When dealing with technology transfer, a COI can lurk anywhere from the sponsorship of research to the nature and timing of published research results. One of the most common scenarios for COI is when the content or timing of published research findings affects license income, funding, or stock value for the financial gain of the investigator or the institution. The following definition, from Francis Meyer of A. M. Pappas & Associates, can help you recognize a potential COI:

> *"A conflict of interest is a situation in which financial or other personal and institutional considerations may directly or significantly affect, or have the appearance of directly and significantly affecting, a faculty or staff member's professional judgment in exercising any university duty or responsibility or in conducting or reporting of research."*

Here are some tips to help you avoid COIs:

◆ Remember that industry is interested in science to increase sales and profits. Altruism and enlightenment are not corporate incentives.

◆ Be careful about your involvement with start-up companies. With a startup, you're more likely to have significant equity in the company, and if the company was founded on your technology, the possibility of a COI increases.

◆ Be careful of what you say during press interviews. It may be better to let the university do the public speaking about your research. Off-the-cuff remarks can present an opportunity for a COI to be perceived where none exists, and the perception can be as damaging to a scientist's credibility and career as the reality.

At some point in your research career you may make a discovery in your lab that has potential commercial application. By having a better understanding of the concepts, processes, and potential pitfalls of technology transfer, you will be better prepared to work with your university's TTO and with industry to bring your discovery to market.

RESOURCES

Association of American Medical Colleges. Reports from Task Force on Financial Conflicts of Interest in Clinical Research, *http://www.aamc.org/research/coi/ start.htm*.

Association of American Universities. Information on intellectual property issues, *http://www.aau.edu/intellect/ipissues.cfm*

Association of University Technology Managers. *http://www.autm.net/ index_ie.html*.

Cech, Thomas R., and Joan S. Leonard. "Conflicts of Interest—Moving Beyond Disclosure." *Science* 291(5506): 989, 2001.

Council on Governmental Relations. Information on intellectual property, *http://www.cogr.edu/files/publications_intellectual.cfm*.

Field, Thomas G. "Intellectual Property: The Practical and Legal Fundamentals." Franklin Pierce Law Center, *http://www.fplc.edu/tfield/plfip.htm*.

Howard Hughes Medical Institute. "What You Should Know About Intellectual Property, Research Collaborations, Materials Transfers, Consulting, and Confidential Disclosure Agreements," *http://www.hhmi.org/about/ogc/downloads/ investigator-guide.pdf*.

Legal Information Institute, Cornell Law School. "Patent Law: An Overview." *http://www.law.cornell.edu/topics/patent.html*.

National Institutes of Health. Information on conflict of interest, *http://grants1.nih.gov/grants/policy/coi/resources.htm*.

U.S. Patent and Trademark Office, *http://www.uspto.gov*.
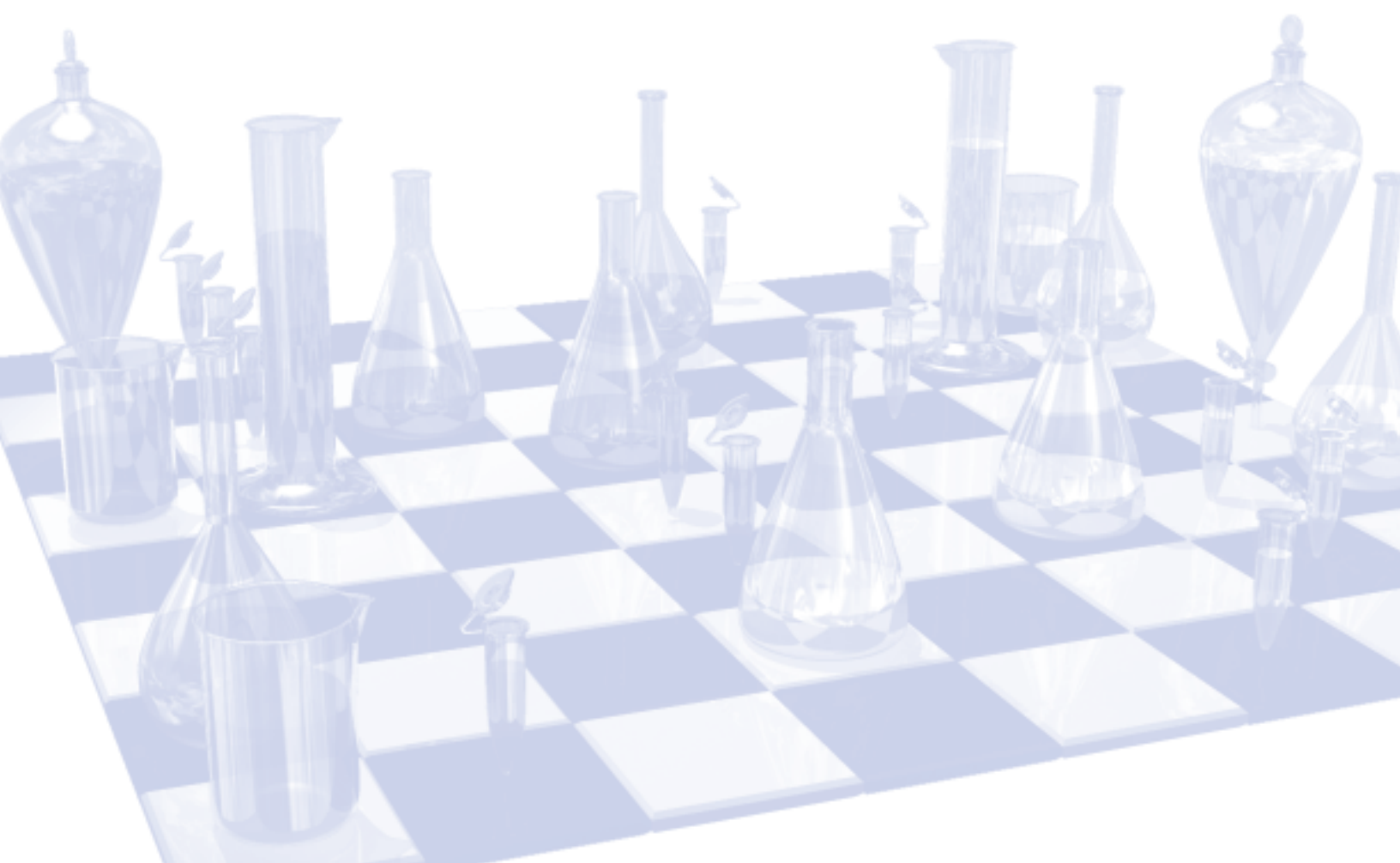
Chapter 12

SETTING UP COLLABORATIONS

Twenty-first century science is often a collaborative effort. As a beginning investigator, you may want or need to work with scientists in other labs who can offer resources or technical expertise to complement your own. Because a scientific collaboration is a complex exchange, you will need to sharpen your managerial and political skills to be a successful collaborator. This chapter summarizes some of the questions you should ask yourself before embarking on a collaborative project and provides some guidelines to help ensure that the project and your interactions with colleagues proceed smoothly.

THE VARIETIES OF COLLABORATION

Collaborators are researchers who share an interest in the outcome of a project, not service providers or customers. Sharing reagents or materials described in a publication does not in itself constitute a collaboration; scientists are expected to make published materials available to others. Similarly, a service rendered by a scientist in a core service facility within his or her own institution is usually not considered a collaboration. The core service facility exists to perform specific tasks for other laboratories.

Collaborations can vary greatly in scope, duration, and degree of formality. A limited collaboration might entail only a series of consultations about a technique or the provision of samples to be tested. At the other extreme, several scientists or laboratories might join together to establish a permanent consortium or center for the pursuit of a particular line of research. Depending on its complexity, a collaboration can be launched by an informal agreement that is sealed with a handshake or an e-mail or by a legally binding document.

SHOULD YOU COLLABORATE?

Collaboration is a major responsibility—one that is not to be entered into lightly. It will take time, effort, and the nurturing of relationships. Before you start a collaboration, you should know for sure that you can see it through. The larger the collaboration, the more complicated fulfilling your obligations may be. Be sure that you are ready to collaborate and that a given opportunity is right for you. Once you've signed on, you will be expected to follow through on your commitments, and your scientific reputation will be at stake.

Assessing a Collaborative Opportunity

Regardless of whether you are approached by another scientist to collaborate or you are thinking of approaching someone to collaborate with you, here are some questions you should ask yourself before embarking on the project:

◆ Do I need this collaboration in order to move my own work forward? Is there a missing piece—a technique or resource—that I must have?

◆ Even if collaboration is not strictly necessary to my current work, will interacting with the proposed collaborators enable me to contribute something significant to science?

◆ Do I really have the expertise or other resources that are sought by the other collaborator?

◆ Can this collaboration be conducted efficiently, given such factors as distance, restrictions imposed by my institution, and, in the case of international collaborations, cultural differences or legal and political complications?

◆ Is there funding for the work envisioned? If not, can it be obtained?

◆ Can I afford the time? How much will it take away from my other responsibilities? Is the project close enough to my central interests to warrant the necessary time expenditure?

◆ Is this person someone with whom I want to collaborate? What is his or her track record? Can someone I trust tell me whether this potential collaborator is honest and reliable?

◆ Are our professional and scientific interests compatible? Does what each of us has to gain or lose by collaborating seem comparable?

◆ Will this person be accessible to me and consistently interested in the project? (There is no point in collaborating if interaction will be difficult. An investigator at a small lab may be a better match than the director of a large operation because a more established scientist is likely to be busier and less in need of the collaboration.)

Question: If I am not interested in a collaborative project with my department chair or someone else who can influence my tenure appointment, how do I decline politely?

Answer: Explain to your chair that you don't have the resources at the moment to enter a collaborative project or that it would not be beneficial to your grad student, who needs to work on a project that is all his or her own. Offer instead to provide input and suggestions into the research and, if possible, suggest other people with similar expertise who may be good collaborators.

◆ In a larger group, will there be a reliable "point person" who is responsible for handling day-to-day issues and small matters?

◆ What exactly is being asked of me? (For example, if someone simply wants your technical expertise or the opportunity to run his or her experiments on your equipment, he or she may not consider you a collaborator at all. The essential ingredient of collaboration is mutual interest in the research outcome. If you have this interest, but the other party assumes that you do not, you may not be treated as a collaborator. This may be acceptable, as long as you understand what you are getting into.)

◆ Can I rule out potential conflicts, either personal or institutional? (For example, you do not want to collaborate with a competitor of your department chair or someone with whom your chair is already collaborating.)

Before making a decision about a collaboration, consider all factors. A good collaboration can take your research in a completely unexpected course; a bad one can siphon off energy and demoralize you.

SETTING UP A COLLABORATION

Someone may eventually ask you to collaborate, but if you are a beginning investigator, it is more likely that you will need to approach a potential collaborator yourself. A collaboration, like many relationships, has no fixed rules; however, there are some guidelines you can follow to ensure that the collaboration starts off on the right foot and proceeds smoothly (also see box "Personal Qualities of a Good Collaborator," page 207).

Approaching a Potential Collaborator

Once you have identified a potential collaborator and decided that you want to go forward, develop an outline of your proposal for the joint project. Define in detail how you think each of you can complement the other's efforts.

Send an e-mail. Make your initial contact with an inquiry designed to whet the other person's appetite. Send a short e-mail describing your research in general terms and asking for the opportunity for a conversation. Do not call on the telephone first—you do not want to put the person on the spot, and you do want to give him or her a chance to find out more about you through personal contacts or your scientific publications.

> " *In your initial e-mail, say up front that you are interested in a
> collaboration. Don't pretend to be asking for expert advice.*
>
> —Tom Misteli, National Cancer Institute "

In your e-mail, focus on the big picture and on conveying your enthusiasm. You
must convince your potential collaborator of the following:

◆ You have the expertise you claim.

◆ You believe that he or she is the best-possible collaborator for the project
at hand.

◆ Both of you stand to benefit.

◆ The whole is indeed greater than the sum of the parts.

Be informed. To make your pitch effective, you need to be familiar with your
potential collaborator's work. Be sure to read the lab's published papers. You will
also need to have a clear idea of what you want to do and of the respective role
each of you will play.

Your e-mail should lead to telephone conversations. After that, a trip to your col-
laborator's lab for a face-to-face meeting is often worthwhile.

The Collaboration Agreement

Using an informal agreement. An exchange of e-mails is usually sufficient to get
a project under way. Before you actually start the work, however, it's best to
develop and agree on a detailed written summary of your joint research plan. The
plan should spell out the following:

◆ The purpose of the collaboration

◆ The scope of work

◆ The expected contribution of each collaborator

◆ Financial responsibilities of each collaborator

◆ Milestones

◆ Reporting obligations

◆ Expectations about authorship

An explicit plan offers several advantages. It prevents misunderstandings, and it
helps keep the project on track. Furthermore, if you expect to apply for funding
for the project, this information can function as a grant proposal. In a collaboration
between two academic labs, the collaboration agreement can simply be e-mailed

back and forth until both parties are satisfied; obtaining signatures could seem overly formal, but it is very important that you conclude these negotiations and reach a clear agreement.

Using a formal agreement. A formal, legally binding written agreement is probably necessary if the collaboration involves a commercial entity such as a pharmaceutical company or a commercial application in which a patent is an expected outcome. You and your collaborator will want to consult with appropriate offices at your respective institutions to help you draft this agreement. This will typically be the technology transfer office or the grants and contracts office; their staff may also arrange for legal review by the institution's attorneys. Make sure to spell out the time period of the collaboration or provide a mechanism by which you can terminate your involvement.

Be aware that if your academic collaborator has financial support from a company for his or her share of the work, the funding agreement may contain restrictions that apply to the collaborative project. For example, the company may have the right to delay publication and to license the results of the collaboration. If the collaboration is an important one for your laboratory, be sure to ask in advance whether your collaborator will use company funding for his or her work on your joint project. If so, you can ask your institution's technology transfer office to help you determine whether there are restrictions that apply to your share of the work. It may be possible to negotiate an agreement that limits the effect your collaborator's funding arrangements have on you. (See chapter 11, "Understanding Technology Transfer," for more information about company-sponsored research.)

THE INGREDIENTS OF A SUCCESSFUL COLLABORATION

Once your agreement is in place and your expectations of one another are clear, you and your collaborator can focus on keeping your lines of communication open and maintaining attitudes of mutual consideration and respect.

Keeping the Lines of Communication Open

An open, trusting relationship is essential if you want to be able to discuss problems candidly and to give and receive critical feedback. In a good collaboration, participants stay in close touch and are accessible to one another. Make it a practice to return your collaborator's calls right away. Make fulfilling your promises to collaborators a significant priority. Don't postpone collaborative commitment for local urgencies that may not have significant impact on your career and scientific reputation.

Meetings. Set up systems to ensure that regular communication takes place. A fixed schedule of face-to-face meetings or conference calls is a must. Also consider setting up occasional videoconferences if your institution and your collaborator's have such facilities. No matter what type of meeting you choose, send out agendas by e-mail, take notes during the discussions, and send out e-mail summaries of the meetings. Include in the summaries "action items" for each collaborator.

Keeping up. Once the project is under way, stay with it. Do not be the "rate-limiting step" that holds things up. When unavoidable conflicts emerge and you can't meet a deadline, let that fact be known right away, so that the deadline can be reset.

Dealing with Authorship and Intellectual Property Issues

Expectations for authorship. Because credit for your work, expressed as authorship of publications, is crucial to your scientific career, you need to pay attention to how credit will be distributed in a collaboration. It's best to discuss expectations for authorship, including who will be first author, before a collaboration begins. This is especially important for trainees in your laboratory whose career progress depends on producing work that gives them clear high priority among a paper's authors. However, agree to revisit authorship as publication nears; the relative contributions of different participants often changes from what was originally envisioned. Once you have a sense of whether the data from your experiments can be published, discuss plans for publication immediately; don't wait until a manuscript draft is prepared.

Pursuing patents. If patents are sought, applications should be filed before the work is presented publicly or is published; otherwise, rights will be lost. Do not jeopardize your own or the other party's intellectual property rights by disclosing your results prematurely.

If your collaboration produces patentable discoveries, you will undoubtedly need to deal with the legal concept of "joint intellectual property." Generally, you will have to assign your ownership in intellectual property to your institution or employer, and your collaborator must do the same to his or her institution. Each party to a collaboration will retain its own "background" intellectual property—that is, the intellectual property it owned before undertaking the project. Each party will also retain the intellectual property rights to discoveries created solely by its own researchers in the course of the project. Joint intellectual property is that created jointly by collaborating researchers. The collaborators' institutions may file a joint patent application that names inventors from both institutions, and the institutions will hold the patent jointly. Often, the institutions will need to reach an agreement on management and licensing of the intellectual property so that any royalties can be shared according to an agreed-upon formula.

If you think a joint patent application is a likely outcome of your collaboration, ask yourself these questions before you begin the collaboration:

◆ What aspects of the proposed project are so interactive that any potential discoveries will be owned jointly?

◆ What aspects of shared work are the property of one laboratory?

◆ When and how will you discuss patents and publications with workers in your laboratories?

◆ Who will take responsibility for, and incur the expense of, filing joint patent applications?

◆ Who will maintain the patents once received?

See chapter 11, "Understanding Technology Transfer," for more information about the patent process, including the effect disclosures can have on the ability to obtain patent rights.

SPECIAL CHALLENGES FOR THE BEGINNING INVESTIGATOR

In the early stages of your career, collaboration can present particular challenges. You are under pressure to get your own research program up and running. You can't afford to let your progress toward tenure be impeded by collaborations that do not yield good results and appropriate credit. You need to keep the following facts of scientific life firmly in mind as you decide about specific collaborations:

◆ If you collaborate with established, well-known scientists, your tenure committee may undervalue your role in the effort. People may assume that you played a minor role, even if you are first author on a paper. For the same reason, collaborating with your postdoctoral mentor may not enhance your reputation as an independent investigator. If you do collaborate with established scientists or your previous mentor, make sure you arrange the collaboration so that the relative contributions of each scientist are made clear in publications and other communications.

◆ The larger the collaborator's lab and the more complex the collaboration, the harder it will be to negotiate first or last authorship. Smaller projects may offer a better chance of getting credit.

◆ If you have special technical expertise that is in demand, you may be inundated by numerous requests to collaborate, even within your own department. Do not allow your time to become so fragmented that your central research projects are neglected. Learn to say no gracefully and, if needed, ask your department chair to offer some protection.

Personal Qualities of a Good Collaborator

Honesty

◆ Disclose anything that might affect someone's decision to collaborate.

◆ Once the collaboration is under way, be willing to "cut through the nonsense" and offer constructive criticism.

Openness

◆ Stay in touch with your collaborator throughout the project, especially when there are problems or delays.

◆ Try to resolve problems with your collaborator directly.

Fairness

◆ Be sure to give credit where it is due.

Industry

◆ Put your full effort into the project.

◆ Carry your fair share of the labor and financial outlays.

Respect

◆ Appreciate your collaborator's contributions.

◆ Never assume that your contributions are more important than those of your collaborator.

Reliability

◆ Deliver what you have promised, on time.

◆ If you engage in multiple collaborations, the probability increases that you will find yourself with a conflict of interest. Especially in these early years, it is better to keep things simple so that you know all the actors and can identify potential conflicts.

When Your Students and Postdocs Collaborate

Your graduate students and postdocs need to learn to collaborate. You can start them off by assigning them joint projects and by guiding them in establishing their expectations of each other and in monitoring the fulfillment of promises. However, you should be prepared to referee, especially when it's necessary to contain inappropriately aggressive members of your group.

It is quite another matter when your students and postdocs approach scientists outside your lab or are themselves approached as potential collaborators. They may have no idea of the politics involved or of the extent of the commitments they are making. Encourage your trainees to look broadly for help and resources, but insist on your prerogative to approve all outside commitments in advance.

INTERNATIONAL COLLABORATIONS

The practical difficulties of international collaboration can be daunting. They include geographic distance, as well as cultural, linguistic, and political barriers. You must be realistic in judging whether you have the energy and resources to make a long-distance project worthwhile. Ask yourself these questions:

◆ How much travel will be required? What will be the costs of each trip in terms of airfare, hotel accommodations, and time away from the lab?

◆ Is travel to this country safe?

◆ How good are the channels of long-distance communication? (E-mail is virtually universal and certainly will help, but if the other lab is on the other side of the world, long-distance telephone conversations will be inconvenient because of the time difference.)

◆ Do I understand the other culture—especially its etiquette of information sharing—well enough to communicate about scientific matters?

◆ Do I know the language of my potential collaborators? Do they have a good command of oral and written English? Will scientific papers be published in another language? If so, how can I vouch for the translation?

◆ What are the country's customs regarding publishing and authorship?

◆ Is the other lab adequately equipped and supported by the country's infrastructure (e.g., electricity, telecommunications)?

Although physical and technical factors are important, it is the human dimension that most often makes or breaks an international collaboration. Be especially sensitive to emotions that may be in play under the surface, especially if your collaborator's lab is less well funded than your own. For example, your collaborators may have concerns about being exploited or disparaged.

Considering these special challenges, international collaboration requires extra dedication. Two key ingredients should be in place at the outset: a stable funding source and at least one individual in the other lab who is as committed to the project as you are and is willing to help push past roadblocks that may arise.

WHEN A COLLABORATION IS NOT WORKING

Collaborations can fail for various reasons. Here are some possible scenarios:

◆ One party loses interest or develops other priorities and intentionally or inadvertently puts the project on the back burner. There's no intent to renege, but deadlines are allowed to slip.

◆ Illness or family problems hinder someone's progress.

◆ Key personnel move on or become uninvolved.

◆ Scientific results are not forthcoming, and the project simply stalls.

◆ Honest disagreements arise about the plan, finances, or authorship.

◆ One or both parties behave badly (e.g., they do not honor some aspect of the agreement, steal credit, or disparage the other collaborator to others).

When such situations arise, you will have to decide how to protect yourself. The worst thing you can do is to allow a bad situation to fester. If you decide your colleague is failing to fulfill the original agreements, get on the phone, or on a plane if need be, and have a straightforward discussion. It is worth your while to try to fix a situation, especially if you have invested significant time and resources in the project. If, however, the other party has lost all interest or you really don't get along, the best thing might be to back out. Although you may be tempted to let your colleagues know about the failure, remember that such a retaliation can harm your reputation as much as that of your collaborator.

If a collaboration doesn't succeed, it's important not to become discouraged. Although collaborations can be a lot of work and, at times, challenging, you will gain much from working with other scientists. Your research can take unexpected turns and expand into new and exciting areas. You will form professional relationships with scientists outside your department who may be willing to write letters of recommendation when it is time to apply for tenure. Your collaborators can help increase your visibility by inviting you to give seminars at their institutes, and they might send graduate students or postdocs to work in your lab.

RESOURCES

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Chapter 13

TEACHING AND COURSE DESIGN

As a new junior faculty member, you might have mixed feelings about taking your place in front of a class. You stare at a sea of faces and think: "What am I doing here? I'm a scientist, not a teacher." Very likely, you feel uncomfortable with teaching because you have never learned how to do it. In this chapter, you will learn how to become a more effective teacher by using a variety of strategies, including "active learning." By experimenting with different teaching methods, continually assessing their effectiveness, and modifying them based upon assessment results, you can become a "scientific teacher" who is as rigorous in teaching as in research. Although the chapter focuses on teaching undergraduates at large research universities and students at medical schools, the methods described can easily be adapted to teaching undergraduates at smaller liberal arts colleges and to teaching graduate students.

This chapter suggests ways to improve your current teaching style by assessing your strengths and weaknesses and learning from colleagues and other professionals. It also offers advice for revising and designing courses, helping your graduate students and postdocs learn to teach, creating a teaching portfolio, and balancing your teaching and research responsibilities.

WHY TEACH WELL

Beyond your contractual obligations, there are important reasons to teach well. Gaining the varied skills required to become a good teacher will benefit you professionally by strengthening your résumé, enhancing your communication skills, and bringing new energy to your lab investigations. You will also contribute to the greater good of society by educating the next generation of students (those who become scientists, as well as those who go into other fields), and you should gain great personal satisfaction by giving a diverse set of students the knowledge, insights, and enthusiasm they need to succeed in science careers. These reasons are explored in greater depth below.

Reasons to Teach

A strong teaching record can help your tenure case. If you are knowledgeable about teaching and can cite evidence that your teaching is effective, the people who are evaluating you will care—or you can make them care. Your ability to prosper in an academic environment will depend in part on your teaching record.

Get to know potential students for your lab. Teaching a class well will likely give you access to top undergraduate or graduate students who may want to join your lab.

Increase science literacy. Increasingly, scientists will be called upon to communicate effectively with the public about complex societal issues, such as genetic engineering or stem cell research, that directly involve advances in science and technology. Teaching will improve your communication skills. In addition, by effectively teaching students who will not be scientists but policy makers, business leaders, and others, you will increase science literacy.

Science needs to retain the best and brightest students. Colleges and universities are losing students from science classrooms at dramatic rates. About 60 percent of students who declare biology as a major do not graduate with that major. The statistics are worse for women and minorities. Often, the students dropping out of science are the ones with very good grades who have gotten the message that science is boring, that teachers already know all the answers, and that there is nothing left to be discovered. By changing your teaching style to one that engages students in the discovery process, you will help change the current trend.

Science needs to draw diverse participants. Heterogeneous groups of people are more effective at problem solving and defending their decisions. To continue to make science a thriving enterprise, we need to attract and retain a diverse community of students and to recognize, appreciate, and satisfy their diverse styles of learning.

Intellectual growth. Ongoing interactions with new students will provide you with new skills and improve on existing ones. For example, teaching will help you improve your communication skills, which are invaluable to research.

Increase job satisfaction. Your science experiments are not always going to go according to plan, and at times you may become frustrated with the pace of research in your lab. Teaching a class may provide you with a much needed distraction and sense of accomplishment.

BECOMING AN EFFECTIVE TEACHER

Teaching the lecture component of a basic science curriculum for medical school students or a year-long microbiology course for undergraduates can be daunting. You want to be well-prepared for this new responsibility. So, how do you learn to become a capable and effective teacher? There are several steps you should take before you even set foot in the classroom.

Assess Your Strengths and Weaknesses

Research has shown that the best teachers are not only knowledgeable about their subject matter, but they also show a concern for students and know how to stimulate interest, encourage discussion, explain topics clearly, and show enthusiasm. Think back to your teaching assistant (TA) days or other teaching experiences you may have had. They might give you some insights into what teaching skills you could improve.

The type of course assigned might not mesh with your scientific preferences, but you should take the time to assess your strengths and weaknesses and take those into account when planning your classes. For example, if you are an extrovert, sharing your enthusiasm for science with students should be easy for you, but you might need to avoid overwhelming students with a rash of complex ideas and, instead, give them more time to pose questions and reflect upon solutions. If you are an introvert, you might find teaching in a large lecture to be so intimidating that you retreat behind your lecture notes and have difficulty interacting with students. If you are given a choice, you can build your confidence by starting with a topic you know well and feel passionately about. After you have established some rapport with students, encouraging give-and-take might be easier for you. Working with small groups is a strategy that should suit your personality. Since good teaching is part art, part technique, and part personality, you will need to find techniques that both fit your personality and address your students' varied learning styles.

Take Advantage of Professional Help

To help you become a better teacher, take advantage of whatever professional assistance your college, university, or medical school offers. Although formal programs aimed at improving learning are still rare, their numbers are rapidly increasing, and many informal programs exist. Some universities offer career development programs for junior faculty; these programs give opportunities for new faculty to build and expand their teaching and other professional skills. Many universities have teaching and learning centers that will give you tips and pointers, offer individual consultations, and videotape your performance as a teacher and suggest ways to improve it. Often, these centers have substantial online resources on curriculum development, teaching techniques, and other issues related to becoming an effective teacher. If your college or university does not have such a center, you can explore the Web to see what's available on other campuses. (A comprehensive list of teaching and learning centers can be found at *http://www.hofstra.edu/faculty/ CTSE/cte_links.cfm*.)

Some professional societies also educate faculty. For example, the National Academies Summer Institutes on Undergraduate Education in Biology, the American Society for Microbiology Conference for Undergraduate Educators, and the American Association of Physics Teachers Workshops for New Physics and Astronomy Faculty are a few examples of available programs that you can investigate.

Observe and Be Observed

Just as you learn to improve your scientific work based on the critiques that editors give to your submitted manuscripts or comments that reviewers make about your grant applications, you can also learn about teaching from peers, senior colleagues, and others at your institution as well as from feedback provided by your students.

Ask a peer for feedback. You might want to consider a reciprocal arrangement with another junior professor in which you visit each other's classes. When you are being observed, ask your colleague to provide a frank assessment of your teaching skills. He or she can give you information and advice informally or by completing a written checklist that contains specific categories, such as structure and goals of the class, teaching behaviors, rapport with students, and subject matter and instruction.

Observe a senior colleague. Seek out senior colleagues who are reputed to be good teachers and ask them if you can attend their classes to see what they do that is effective. If you would like a faculty member to observe your teaching, and possibly serve as a "teaching mentor," choose someone who seems enthusiastic and knowledgeable about teaching at departmental meetings and who has developed a reputation for creative teaching. Experienced colleagues can offer suggestions for dealing with particular topics and give you additional ways to clarify and enliven the material.

Enlist an outside observer. An instructional consultant on your campus might be available to be an outside observer. Although the consultant might not be familiar with the content of your science courses, he or she usually has enough teaching expertise to comment on your techniques and give you suggestions.

Seek feedback through a formal peer review project. As you become a more experienced teacher, you might want to participate in more formal peer review of teaching projects, which aim to engage faculty in capturing the intellectual work of teaching by helping instructors document, assess, and reflect upon ways to improve student learning and performance. (A list of peer review projects and ideas can be found at *http://cte.umdnj.edu/career_development/career_peer_review.cfm*.)

Ask your students for feedback. Student evaluations of teaching effectiveness, now required at the vast majority of college campuses, can offer valuable clues as to what you are—and are not—doing well. However, many standard assessments, which contain quantitative questions designed to be analyzed by computer (e.g., "Overall, how would you rate the quality of the instructor's teaching?"), might not provide enough specific information. You might want to create an informal survey, with plenty of room for comments. The students' critiques can help you make any necessary course corrections. Bear in mind, though, that student ratings for your first course might be low but should quickly improve as you gain experience and confidence as a teacher.

PLANNING TO TEACH A COURSE

The following sections of this chapter will describe the concept of active learning, how to design a science course, and how to involve TAs in the process. But before you can even start writing your course outline or think about how many active-learning exercises you want to include in your lessons, you should ask yourself, What will the course accomplish? Below is a possible answer.

The goals of this course are

◆   *to teach the following three components(x, y, and z) in a deep and meaningful way;*

◆   *to sustain the interest of students who are planning to major in science;*

◆   *to provide an understanding of the method and principles of the scientific process for those not continuing with the subject; and*

◆   *to provide a strong preparation for the next course in the series.*

Once you have clearly defined the goals for the course, the next question you need to ask is, "How will I know I have accomplished these goals?" Methods for assessment are discussed in the section "Assessing Student Learning," on page 223. But keep in mind that assessment is something you need to think about from the start of the planning process. It is an important component of designing a course rather than something that is tacked on at the end.

THE PRINCIPLES OF ACTIVE LEARNING

Whether you teach at a large research university a medical school, or a smaller, liberal arts college, you can aim to create a classroom that reflects the process of science and captures the rigor, iterative nature, and spirit of discovery of science at its best. (See the box "Active Learning in Small and Large Settings" on page 216.) Active-learning strategies are at the core of this approach.

> *People learn best when they can apply knowledge to a practical situation immediately.*
>
> —Jo Handelsman, University of Wisconsin–Madison

What Is Active Learning?

Active learning uses a variety of problem-solving techniques to help students become active participants in the learning process, giving them the chance to clarify, question, apply, and consolidate new knowledge. The concept was originated by John Dewey, a philosopher of education who contended that learning must be built upon the experience of the learner, who actively integrates new knowledge into an existing conceptual framework. Today, broad support exists for the core elements of active learning, and a growing body of research has made it clear that supplementing or replacing lectures with active-learning techniques and engaging students in discovery and scientific process improve their abilities to understand concepts, think critically, and retain knowledge.

In the classroom, the principal tools of active learning are

◆ *Cooperative learning:* Students work in groups and the teacher is the facilitator. Cooperative learning builds a sense of community in the classroom that enables students to work together in noncompetitive ways.

◆ *Inquiry-based learning:* Students ask and answer questions and engage in the process of science.

◆ *Assessment:* The instructor continually assesses what students are learning and uses the feedback to make revisions as the course progresses.

Active Learning in Small and Large Settings

Active learning presents different opportunities and challenges, depending on the size of the institution at which you teach, and the format of the class you are teaching. At a liberal arts college, small classes and frequent contact with undergraduates, both in and out of class, will make a range of active-learning techniques easier to employ. At a large research institution, with much larger classes and far less contact with undergraduates, you will have to try harder to introduce active-learning strategies and assessments, particularly in introductory science courses. In addition, many classes are "team taught," and getting agreement to use active learning in the classroom from all team members might be a challenge. Upper-level courses and other small-size classes are excellent opportunities for departures from straight lectures. The information in this chapter offers many workable techniques to change your lectures into more dynamic experiences for students. Although you might not teach the labs associated with your courses, you can train the graduate students teaching your tutorials or lab sections to use a range of inquiry-based strategies to help students understand the practice of science.

Implementing Active Learning in the Classroom

Most scientists will have experienced learning as undergraduates or even graduate students with the "sage on the stage" approach. If you are like most, delivering a lecture is the way of teaching that will be most natural to you. You can, however, start to integrate some active-learning components in your lectures to make the material more engaging to your students. You might lecture for 10 to 15 minutes and then carry out an activity, or conduct an activity first and then lecture for another 10 to 15 minutes. You might present the results of a scientific study and

ask students to make a prediction, or ask students to write the most important concept they learned in the class on a note card. Or, you could present the class as a whole with a problem and ask students to consult and debate with other students who are sitting near them and then report to the whole class—a strategy that requires students to critique the understanding of others in the group and to explain concepts to each other. (Three useful articles on effective lecture preparation and delivery can be found at *http://www1.umn.edu/ohr/teachlearn/guides/ lecture1.html, http://www.ncsu.edu/felder-public/Papers/Largeclasses.htm*, and *http://teaching.berkeley.edu/bgd/largelecture.html*.)

As you incorporate active learning in your classroom, keep the following pointers in mind:

Don't try to cover too many topics. To make active learning work well, especially within the large lecture format, pare down each lecture to the core concepts you want or are required to introduce and organize the concepts in a meaningful sequence. (See page 226, "Course Design," for more about course structure and organization.)

Provide an appealing context for the concepts you highlight. While you might find a lecture on metabolic pathways exciting, your students would probably prefer to learn about an absorbing case problem to which the metabolic pathway might hold a key.

Start gradually and then add more. You can introduce active-learning components slowly and experiment with different ways of teaching the material to engage students. For example, you could start by stopping your lecture for a few moments to ask students questions, which you can formulate in advance, about the content you are teaching:

- ◆ *Description:* What do you see? What happened?

- ◆ *Common purpose:* What is the purpose or function of?

- ◆ *Procedures:* How was this done? What will have to be done?

- ◆ *Possibilities:* What else could…? How could we…?

- ◆ *Prediction:* What will happen next?

- ◆ *Justification:* How can you tell? What evidence led you to…?

- ◆ *Rationale:* Why? What is the reason?

- ◆ *Generalization:* What is the same about…and…? What could you generalize from these events?

- ◆ *Definition:* What does…mean?

Encourage student questions.

◆ Don't ask, "Any questions so far?" Rather, answer a question with a question to encourage students to define concepts in their own words. For example, if a student asks, "What is polymerase chain reaction (PCR)?," answer the question but then ask a related question that will test the student's ability to apply the knowledge that you just gave them: "Can anyone think of why a researcher would want to use PCR?"

◆ Encourage students to question concepts, ideas, and theories by using examples from your own research to explain how the scientific process is carried out.

◆ One of the problems of asking someone to answer questions in class is that it can become a private conversation with a few students who volunteer answers. Instead, you may try asking students to write the answers individually or work on the answers in a group.

◆ At the end of a class, ask students to write down two good questions or test problems related to the material you presented, and start your next lecture with a reference to those questions. You can also ask a question that can be answered by those who read the material for the next class, and then ask any student to present his or her answer at the beginning of the next session.

◆ Use Web-based resources such as a discussion board to encourage students to go through the reading material before class and come up with questions.

Question: How do I get students to respond to my questions and not be met with thundering silence?

Answer: Make it clear that you expect participation, but develop the patience to deal with at least 10 or 15 seconds of silence when you ask a question. Even if you feel frustrated when no one speaks up, refrain from answering the question yourself, or you will set the wrong tone for the rest of the course. Frame an opening question in the form of "Choose one of these answers." Call for a vote, either by a show of hands or through the "clicker" system described on page 223. To encourage more discussion, ask students to explain why they voted the way they did.

Use a variety of in-class exercises.

◆ Assign a task and give students—working in pairs or small groups—time to write responses. You can also ask students to work individually and then to form pairs in order to combine and improve their individual responses (called the "think-pair-share" approach). Then you can randomly call upon a few pairs to give brief summaries of their joint answers. (For general guidelines and suggestions for paired activities, go to the University of Minnesota's Center for Teaching and Learning Services at *http://www1.umn.edu/ohr/teachlearn/ guides/active.html*.)

◆ Use case-based problems that develop critical thinking and analytical behavior. Find examples of cases that are meaningful and relevant to students— on topics such as human pathologies, bioterrorism, cancer, genetically modified foods, mad-cow disease, or other current issues. Use cases not only to

teach concepts but also to start students thinking about the relevance of science and its impact on society. (For examples, go to The National Center for Case Study Teaching in Science, which has case ideas and a case study collection, at *http://ublib.buffalo.edu/libraries/projects/cases/case.html*.)

◆   Ask students to create a drawing, diagram, or chart to help explain an idea, relationship, or process. Tell them to share their drawing and discuss it with a classmate.

Use real-world examples.

◆   Use current newspaper and magazine articles to show the relevance of the topics students are studying. For example, if you are teaching about DNA sequencing, bring in articles about the sequencing of the human genome or ask students to locate relevant articles by searching the Internet and bring them to class.

◆   Involve the class in assessing the biological implications of a real or planned community project, such as a plan to control communicable diseases or to manage the deer population. Assign student groups to investigate various aspects of the project, collect field data, and present evidence-based recommendations to the class.

Use technology to enhance teaching.

◆   Provide some historical background to key discoveries in biology by showing films or news clips of early, groundbreaking experiments.

◆   Integrate new media technology such as animations or virtual labs to make biology more vivid and accessible to a generation raised on video games. Slides, photos, and film clips will also get your students' attention and will open familiar material to surprising new questions.

◆   Use interactive demonstrations and simulations to illustrate concepts. Or show maps, photographs, or diagrams and ask students to make their own observations and interpretations.

◆   Use an online discussion/bulletin board as a forum to talk about ideas. Be active in the discussion without dominating it.

◆   Engage students by having them use electronic keypads (clickers) to answer your questions (see page 223 for more about clickers).

◆   If you decide to use PowerPoint in class, learn to make your presentations visually dynamic and engaging to students. (For an online tutorial on active learning with PowerPoint, go to *http://www1.umn.edu/ohr/teachlearn/ workshops/powerp*.)

Set the stage for active learning.

◆ Arrange the lecture classroom to encourage active participation. If chairs are bolted to the floor and cannot be moved, use a microphone with a long extension cord so you can move around the lecture hall while you are talking and listening. If chairs can be moved, arrange them in circles and banish the lectern to a corner of the room.

◆ Set the pattern for active participation from the very first day. Remind students of the value of active learning, ask questions that call for genuine discussion, and get students talking several times during the first session.

◆ Learn as many students' names as you can. At the first class, tell students to choose their seats for the semester and then make a seating chart, which you can study while students are working on in-class exercises.

Going from Passive to Active

It's easy to shift from making passive statements in a lecture to asking questions that encourage student discussion. Here are two examples:

◆ *The passive approach:* Every cell in an organism has the same DNA, but different genes are expressed at different times and under various conditions. This is called gene expression.

◆ *The active learning approach:* If every cell in a plant has the same DNA, how can different parts of a plant look different? Work with a neighbor to generate a hypothesis.

OR

◆ *Passive:* Based on the data shown in this slide, researchers concluded the following.

◆ *Active:* Let's look at the data from this experiment I just described. Which of the following conclusions can you draw from the data? Let's take a vote and then discuss it.

Source: Jo Handelsman, University of Wisconsin–Madison.

Active Learning in the Lab

The college laboratory is the perfect place for students to actually practice science by designing experiments, gathering and analyzing data, and presenting their findings. Too many labs rely on "cookbook" experiments—experiments that have been done thousands of times before and whose outcomes are already well-known. What do students learn from cookbook experiments? They chiefly learn to follow instructions so that they can complete the lab successfully and earn a good grade.

If you want your students to experience the thrill of science, consider taking a different approach by either designing or adapting existing inquiry-based experiments. When they are properly designed with discovery-based learning activities, labs can provide rich learning experiences for students that help them develop a variety of professional and technical skills.

Most inquiry-based labs begin with a question—either one generated by the teacher or preferably one generated by the students—that provides students with a specific issue or topic to explore. Students research the topic, offer a hypothesis, design an experiment to test the hypothesis, analyze the collected data, and determine if their hypothesis was confirmed. The students then present and explain their findings to the class as a whole.

As students start to understand and apply the scientific method, they can begin to experience the joy of discovery. From inquiry-based labs, students can also develop better communication and critical-thinking skills and learn to work together as part of a problem-solving team.

A well-designed inquiry lab takes time and resources to develop, however, so it might be best to start small. Below is one example of an approach you can take to "uncooking the lab," and you can find additional ideas, tools, and references for developing inquiry-based labs at *http://scientificteaching.wisc.edu/products/Uncook_handout.pdf*.

In a standard laboratory exercise, students may be instructed to make 10-fold dilutions of soil samples and apply each solution to a culture medium. After incubation, students count the number of colonies on each plate and calculate the number of bacterial organisms in the sample.

A similar laboratory exercise using an inquiry-based approach would ask students to bring in two soil samples. The instructor would then challenge the students to generate a hypothesis about the microbes in the soil samples and design an experiment to test it.

ACTIVE LEARNING AT A MEDICAL SCHOOL

Many of the principles of using active learning discussed above apply to teaching at a medical school, but, as an instructor, you must be aware of the challenging examinations your students will soon face and their need to be rigorously prepared. Medical students carry a heavy course load in the basic sciences during most of their first two years, but unlike undergraduate students, who take exams prepared by their teachers (or, occasionally, by their departments) on specific semester-long courses, medical students completing their second year take step 1 of a national exam—the three-part United States Medical Licensing Examination (USMLE)—which will test their knowledge of basic sciences and their ability to interpret data. (This is in addition to one or two midterm tests as well as a final examination.) After the fourth year of medical school, they take step 2 of the USMLE, which will test their knowledge of clinical care and their ability to interpret clinical data.

In incorporating active-learning components, you should carefully consider two fundamental educational needs of medical students: to master core science concepts and to gain the skills they will need to become doctors. One good approach is to couple a lecture—which might be necessary to explain core concepts—with a small-group discussion of a medical case or disease—a method called case-based learning.

> *Most of us use lectures because it's what we know. If teaching is to be considered valuable and not just necessary, we should invest the time to design active-learning strategies. These strategies don't have to be done in the absence of lectures; they can be used when students break up into small groups for case-based discussion following a lecture.*
>
> —Curtis Altmann, Florida State University College of Medicine

Case-Based Learning

Case-based learning allows students to learn science in a very practical way, by exploring the kind of issues they might actually confront in medical practice. Students meet in small groups with a faculty member who acts as a facilitator. They are then assigned roles, such as discussion leader, reader, scribe, or timekeeper. For each case, which they will have read and thought about ahead of time, they receive a list of objectives; a narrative description of a medical issue, a disease, or an advance in biomedical science; and a list of questions to address and problems posed by the narrative. The exercises are designed to integrate previously learned curriculum content, so students are expected to refer to material they have studied before to answer the questions. In addition, students are encouraged to pose hypotheses, access information on the Internet, present new information, reach conclusions as a group, and evaluate each exercise. Typically, each group completes two exercises in every two-hour session.

Your role as facilitator. In a case-based learning setting, you role is likely to be that of a faculty facilitator. Your goal should be to assist your group to function smoothly to maximize learning. You should not assume the role of an instructor or a lecturer, but should, in fact, consider yourself a co-learner who happens to be especially experienced in scientific inquiry and in assisting others to learn. You should, however, correct any misinformation that might arise during student discussions. Below are some tips for facilitating successfully (obtained from *Guide to Small Group CBL Exercises, BMS6204: Medical Biochemistry and Genetics,* Florida State University College of Medicine).

◆ Encourage the group to recognize and formulate problems—by asking students to brainstorm and make a list of possible causes of the disease being discussed.

◆ Give group members opportunities to demonstrate their learning—by asking them to describe new information they might have learned from the Internet or other research.

◆ Ensure that all group members have a chance to contribute—by delaying the "talkers" from answering too quickly while encouraging quieter students to participate. If that strategy does not work, break up the larger questions into smaller segments and go around the room, calling on each student. Don't dominate the discussion.

◆ Encourage the group to critically evaluate ideas—by asking probing questions and suggesting other avenues to explore.

◆ Provide timely, constructive feedback—-by helping the group analyze what went well and what went wrong in the discussion.

◆ Model respectful and professional behavior—by showing respect and support to all students while making the rules of small-group discussion very clear.

ASSESSING STUDENT LEARNING

Assessment is an important part of your job as a teacher, as you will use the information to evaluate students and also to determine what teaching strategies worked best and which ones you want to refine. While you can use end-of-semester multiple-choice examinations as one evaluation component, you will also want to use small, more frequent, and informal assessments of knowledge. So-called "active" assessments can give you frequent readings on students' levels of understanding, so that you can make midcourse corrections when you see the need. (See appendix 1 for a variety of ideas for active assessments that are easy to use.) You can also get immediate feedback by using innovative technology such as clickers to ask students questions and find out how much they know or don't know.

Clicker Technology

"Clickers," known as personal, audience, or classroom response or performance systems, allow teachers to inject active learning into a lecture and to immediately assess whether students understand the material being presented. The clicker technology can also be used to create multiple-choice and other questions, to take attendance, and to grade quizzes and exams.

Similar to a television remote control, the clicker is a wireless handset with a variety of response buttons. Students use it to answer questions posed by the instructor. Their answers are sent by infrared signals to a receiver, where the data are instantly tallied and analyzed by a computer, and the results are displayed graphically. Teachers can display the responses on a screen, post them on a Web site, or save them for later reference. Students can respond anonymously or can be identified by a serial number in each transmitter.

Several manufacturers, including GTCO CalComp in Maryland and eInstruction Corporation in Texas, offer the technology. Prices vary depending on arrangements an institution might make with a manufacturer or a textbook publisher, if the clicker system is used with required texts.

If you are interested in using the technology, contact your campus teaching and learning center or instructional technology department. (For an article about one university's use of classroom clickers, go to *http://www.news.wisc.edu/11142.html*.)

Bear in mind, however, that it is not always easy to tease out the specific impact of your innovative learning techniques. In a classroom setting, you will generally not be able to implement a true experimental design, in which students are randomly assigned to different groups, where only one variable (the learning innovation) changes. However, by using a variety of techniques, such as pretests and control groups, you might get a better sense of the ways in which your active-learning strategies are improving your students' learning. (For a more in-depth discussion of these issues, challenges, and steps involved in developing and appropriately using assessment tools, see the articles on assessment and educational research at *http://www.aaas.org/publications/books_reports/CCLI*.)

Developing Exam Questions

Regardless of the types of assessment tools you favor, you will not be able to escape midterm and final examinations. Bloom's Taxonomy (described more fully in appendix 2) can be a useful guide for preparing examination questions. It depicts six successive levels or categories of learning—knowledge, comprehension, application, analysis, synthesis and evaluation—that ascend in difficulty from factual knowledge to evaluation. Many tests that faculty administer rely too heavily on students' recall of information. But Bloom contended that it is important to measure higher learning as well.

Use a wide variety of questions to evaluate students' different content and skill levels so you can make sure students are deepening, broadening, and integrating their knowledge as well as learning factual information. Here are some standard kinds of test questions, with their advantages and disadvantages and correlations to Bloom's Taxonomy, obtained from the University of Wisconsin Teaching Academy Short Course in Exam Question Types and Student Competencies (*http://wiscinfo.doit.wisc.edu/teaching-academy/Assistance/course/questions.htm*).

True/false questions. These present a statement and ask the student to decide whether the statement is true or false. While the tests are among the easiest to write and score, they are limited in the kinds of student mastery they assess and have a relatively high probability of students guessing the right answer. They correspond to Bloom's levels of knowledge and comprehension.

Short-answer questions. These are "constructed response" or open-ended questions that ask students to create a short answer (one sentence or several sentences), fill in a blank, or complete a sentence. Although the questions are relatively easy to write, they are harder to score because students are free to answer the question in any way they choose. They correspond to Bloom's levels of knowledge, comprehension, and application.

Multiple-choice questions. These present a question and ask students to choose from a list of answers. Questions can be statements or complex cases or scenarios that require careful consideration on the part of students. The questions can be more challenging to answer (if they require both one correct answer and several false "distracter" questions) but easy to score. They correspond to Bloom's levels of knowledge, comprehension, application, and analysis. (See the box "Multiple-Choice Questions" for an example of a case-based multiple-choice question.)

Essay questions. These allow students to focus on broad issues, general concepts, and interrelationships, rather than on specific facts or details. The advantage is that the tests allow you to see the quality and depth of each student's thinking. However, they can be difficult and very time-consuming to score, because the answers vary in length and variety and you might tend to give students a better grade if they have strong writing skills. Essay tests can effectively assess all six levels of Bloom's Taxonomy.

If you find Bloom's Taxonomy too cumbersome to use, you can choose a simplified version that collapses the taxonomy into three general levels:

◆   Knowledge (recall or recognition of specific information)

◆   Comprehension and application

◆   Problem-solving, or transferring existing knowledge and skills to new situations

Other types of exams. You can also consider using alternative types of exams, such as group exams, which can be given either in class or as take-home exams and which use open-ended questions that have no right or wrong answers. However, since you will be giving each individual a grade for the course, you will want to allow each student to write an answer to a question or questions, as well as to participate with the group.

Whatever exam or combinations of exams you use, remember that writing exam questions takes time; don't try to "throw it together" at the end. Before you start, make sure you ask your institution if it has any established formats to which your exam questions must conform. For example, in medical schools, tests might need to conform to standards set by the Liaison Committee on Medical Education, which accredits medical schools in the United States. Think carefully about the learning outcomes you want to measure, so you can match your questions to the content. If you are working with graduate students who are your TAs, involve them in writing the exam or in reviewing a draft of it to make sure your instructions are clear and that the test can be completed in the time allowed. (For a comprehensive book chapter on quizzes, tests, and exams, go to *http://teaching.berkeley.edu/ bgd/quizzes.html*.)

Multiple-Choice Questions

Short case studies that use authentic data can make powerful multiple-choice questions that test scientific literacy and fluency, as well as core concepts. Here is an example:

The sexually transmitted disease gonorrhea is becoming difficult to treat because the causative bacteria, *Neisseria gonorrhoeae,* are evolving resistance to antibiotics. For example, in Hawaii between 1997 and 1999 resistance to fluoroquinolones increased from 1.4 to 9.5 percent. Scientists attribute this to natural selection. What does natural selection mean in this context?

A. *Neisseria gonorrhoeae* have learned to avoid that particular class of antibiotic.

B. The antibiotic has changed the genetic structure of the *Neisseria gonorrhoeae,* allowing them to become antibiotic-resistant.

C. The *Neisseria gonorrhoeae* changed their genetic code in order to avoid being killed by the antibiotic.

D. The antibiotic created an environment in which *Neisseria gonorrhoeae* harboring antibiotic-resistant genes could thrive at the expense of those susceptible to the antibiotic.

E. The mutation rate for antibiotic resistance increased during this time period.

[Answer: D.]

Source: *http://www.saltspring.com/capewest/mc.htm*.

COURSE DESIGN

Some of you will be asked to design a new course from scratch or will want to redesign an existing course to better suit your teaching style and knowledge. Since course design is a complex and time-consuming undertaking, give considerable thought to a wide range of issues and questions before starting down this path.

> *I would highly recommend that you try, when you are assigned a course, to negotiate up front to be able to teach it for three or four consecutive years. That way you will make the most of the time and effort you put into preparing your material and will have a chance to refine it each year.*
>
> —Thomas Cech, HHMI

Improving an Existing Course

As a new teacher, you will most likely be asked to teach a course previously taught by another faculty member. You might find that the course is a perfect fit for you and that you will have to change very little. More likely, however, you will want to undertake some revisions. Here are some tips for helping you achieve your goal:

Do your homework.

◆ Clarify your department's expectations for this course. If you are teaching a course for only one year and must hand it back to your colleague when he returns from a sabbatical, you might want to invest minimal time and effort. If you can get a commitment to teach the course for several years, revising it will make more sense.

◆ Review and evaluate the course syllabus, lecture notes, textbooks, and other assigned readings, assessment questions, and other materials the faculty member who previously taught the course will make available to you.

◆ Review students' final exams to learn where the course was strong or weak in teaching key concepts. Skim a few years' worth of students' course evaluations if they are available.

◆ If possible, ask the faculty member who is turning the course over to you to describe his or her impressions of what worked and what didn't, or observe this person teaching a class and jot down your thoughts about what you would keep or change.

Determine what changes to make. If you do decide to make changes to the course, figure out what and how much you want to change. Even if the faculty member who previously taught the course makes his or her notes available to you,

you should rewrite them in your own style. This will help you master the material and allow you to insert your own examples and active-learning exercises.

If the content of the course seems satisfactory overall, you can focus more on your presentation. But if you think it's necessary to introduce a substantial amount of new content or make major structural changes, then it may be helpful to read the section below on designing a new course.

Remember that it's advisable to make changes incrementally, based on student feedback.

Designing a New Course

Creating a new course is more difficult and time-consuming than revising an existing one. Before starting, ask yourself why you want to design a new course. Has your department chair requested you to fill a gap—and can you earn good will for being viewed as a team player? Do you have a special research interest that is not represented in the curriculum? If so, can you acquire educational support funds that will enable you both to teach the course and buy a piece of equipment for your research lab that can also be used in the lab component of the course?

Most large research schools allow new faculty members one or two semesters to set up a lab and write research grant applications. Liberal arts colleges may not be able to give such an opportunity. Try to at least negotiate part of your workload during the first semester to allow you the time to construct the course so that you can teach it second semester. If you try to do too much too soon, the balance of your teaching and research responsibilities might get out of sync.

You will face three critical decisions: what to teach, how to teach it, and how to ensure that students are learning what is being taught. Ideally, you should begin planning your course several months ahead of the semester in which it is taught to give yourself time to order textbooks and request other resources and prepare your course handouts. But even if you are assigned a course at the last minute, you can still use many of the planning guidelines described below.

Determine what to teach.

1. Determine how the course relates to other courses in the departmental curriculum by asking these questions:

◆ Will the course be a prerequisite for higher-level courses? If so, talk to the instructors of the advanced courses to see what kinds of knowledge and skills they expect from students.

◆ Is it an advanced course? If so, talk to the instructors who are teaching prerequisite courses so you can better understand what skills students will have when entering your course.

◆ Are there major departmental changes under way that might affect your course? If, for example, your university is considering new approaches—such as doing away with introductory biology and chemistry and replacing them with a multidisciplinary life sciences course—you will want to keep that long-term agenda in mind.

Knowing how your course fits into the entire structure is important and will call for discussions with other faculty and perhaps a collaborative or interdisciplinary approach.

2. Establish course content goals. Identify three to five general goals (e.g., "understanding the concept of antibiotic resistance") for the course that will explain what you want your students to know and do when the course is over. If you include noncontent goals (such as "work collaboratively with other students"), keep in mind that these are harder to assess.

3. Identify major course themes. These principles or fundamental postulates lend continuity and provide perspective on the entire course. For example, a year-long course in introductory biology might involve three broad themes: information and evolution in living systems, development and homeostasis, and energy and resources.

4. Identify core concepts within your major themes. Try to provide a balance of concrete information and abstract concepts, and balance material that emphasizes practical problem-solving with material that emphasizes fundamental understanding.

5. Define the objectives of individual units or lessons. For example, one objective might be that students will be able to propose tests of evolutionary hypotheses or critique arguments pertaining to evolutionary evidence. Such definitions will help structure the content of each lesson

Note: Your opportunity to develop new courses in a medical school will likely be very limited due to the need to prepare students for the USMLE step 1 exam.

> *When you plan your course, don't overdo it. We feel we have so much to teach, but when we impart too much knowledge, students get the impression that everything is known and that there is nothing interesting left for them to discover.*
>
> —Manju Hingorani, Wesleyan University

Determine how to teach it.

1. Determine the general structure of your course. Ask yourself these kinds of questions:

◆ What combination of lecture and assignments, lab, seminars, and journal club do you want to use?

◆ What will be the balance of faculty lecture and demonstrations versus student presentation or student-led discussion or laboratory work in the course?

◆ Can you incorporate any extracurricular activities into the course to enhance learning?

◆ Do you want or have to include other faculty presenters?

2. Select resources. Choose textbooks—-using letterhead to contact publishers for review copies—and journal articles, and investigate the use of technology enhancements, such as animations, videos, simulations, or virtual labs. Make sure the textbooks match your idea of the goals and objectives, or be prepared to tell students how to make the best use of the reading resources. Think about guest speakers or faculty members who might be appropriate and willing to teach several classes. Determine what other resources you need—such as TAs, laboratory space and supplies, and library resources—and determine whether these will be available.

3. If you plan to have a Web site for your course, familiarize yourself with your institution's course management system, which will enable you to put various components, such as lecture notes and discussion forums, online. See the box "Setting Up a Course Web Site" for further details.

Setting Up a Course Web Site

Increasingly, faculty members are using Web-based course management systems (CMSs) to deliver entire courses or certain components of courses online. In essence, a CMS allows an instructor to post information on the Web without having to know HTML or other computer languages and provides a set of tools and a framework for teaching and managing the course and evaluating student progress. Such a site can also be used to field questions from students and then to post answers for all others to see. For ideas about using a CMS to its fullest potential, see "Course Management Systems and the Reinvention of Instruction," by Craig Ullman and Mitchell Rabinowitz, at *http://thejournal.com/magazine/vault/A5070.cfm*.

CMSs can be commercial, campus-specific, or open source. (Open-source systems have no upfront license fees, but the software is not necessarily free.) Popular systems include those developed by Blackboard (*http://www.blackboard.com*), Moodle (*http://moodle.org*), and the Sakai Project (*http://www.sakaiproject.org*). To learn more about the different CMS options that are available, you can go to EduTools (*http://www.edutools.info/index.jsp?pj=1*). Speak with colleagues and administrators to determine what is already available at your campus. To see the components of one university's Blackboard support site, go to *http://www.utexas.edu/academic/blackboard*.

4. Determine how you will assess student learning for each goal. Do this on the basis of the goals of the course. You can use the kinds of "active assessments" described in appendix 1, as well as more traditional quizzes, in-class or at-home examinations, papers, problem sets, in-class presentations, and projects.

5. Divide the course into manageable pieces. Divide the larger units into individual class sessions with objectives, methods, and evaluations for each. Choose activities for each class and create a table or grid for each class to plan each of these elements.

6. Check your college or university's calendar. Look for exam dates, holidays, and other events that might affect class schedules. Try to avoid having sessions that cover related material span major holidays.

7. Prepare your syllabus using the checklist below as a guide.

- Name of the course, number of credits, classroom meeting place and time, and semester and year the course is given

- Name and contact information for you and any other faculty or TAs involved

- Course Web site, if there is one

- A brief course description and statement of overall course goals

- A brief statement of objectives

- A description of course format

- A statement of assessment techniques

- A schedule of class dates and topics

- A schedule of due dates for papers, tests, and projects

- Pertinent information about academic policies and procedures such as class attendance, make-up assignments, late work, group projects, and grading

Determine if students are learning.

Feedback can be obtained by reviewing student performance; student evaluations, from informal consultations with students; and evaluations from your peers. In addition, you might want to have an informal consultation with your teaching mentor. It might be useful to conduct such evaluations periodically during the course, particularly if it is a new one.

Once you have taught your course, you will probably want to revise it based on your sense of whether the objectives were met and on feedback from students and colleagues, but resist the urge to change or correct everything all at once. Instead, make small adjustments over time.

TEACHING OTHERS TO TEACH

As principal investigator of a laboratory you will mentor graduate students and postdoctoral fellows to be successful in the lab and in their future endeavors. You may also have opportunities to help them get teaching experience and improve their skills as teachers.

Teaching the Teaching Assistants

Graduate student or postdoctoral fellows are often so immersed in their own research projects that they may regard teaching as something to stay away from or to quickly get out of the way. You will need to reinforce the value of teaching effectively—for the sake of their own careers and the undergraduates they teach—and involve them in the process of developing a course. Start by scheduling weekly (or more frequent) meetings with all TAs. At these meetings you can describe your goals for the course and for the coming week, and give TAs an opportunity to discuss problems they are encountering and ask for your advice. Other ways to get them involved include the folllowing:

Encourage TAs to seek professional training.

◆ Encourage TAs to take advantage of any formal training offered by your college or university, which can range from a short orientation to a week-long program.

◆ Invite faculty from other disciplines or outside speakers who can talk about such topics as inquiry-based learning or the innovative educational projects in which they are involved.

Foster "scientific" teaching.

◆ If you are developing a new course, build in a component that is designed to be taught by a TA. Be sure to provide TAs with all resources (e.g., textbooks, readings, your lecture notes) necessary.

◆ Review a range of active-learning strategies and assessments with TAs, and brainstorm about which ones might work best.

◆ Don't expect TAs to be comfortable using teaching techniques that they have never used as students. Demonstrate active-learning techniques with the TAs being the students. You may spend only an hour running through a few examples, but it will make the difference between your TAs shying away from these methods and being willing to experiment with them.

◆ Help TAs understand that teaching is an experimental situation and emphasize that they don't have to be perfect teachers. Scientific teachers continue to experiment and revise their courses, even after years in the classroom.

Support TAs' classroom efforts.

◆ Visit sections led by TAs often and offer useful feedback soon after you visit, but be sure to provide the feedback privately to the TA.

◆ Before allowing a TA to grade papers, circulate a sample of papers and have each TA grade them independently, using a rubric developed in advance. Devote a TA meeting to discussing and resolving differences in grading on that sample.

◆ Tell your TAs to come to you when serious problems arise—such as encountering students with obvious behavior or psychological problems or situations that could lead to litigation or violence. Direct your TA to the right professionals on campus or call in the professionals to help resolve the situation.

◆ Be sure you brief your TAs on professional standards of behavior, such as treating students with fairness; maintaining confidentiality (e.g., not talking about students with other students; not talking about students in public places); refraining from socializing with students (including, but not limited to, dating them); and conducting meetings with students in an office with the doors open and other people around to protect themselves from being physically vulnerable or falsely accused of inappropriate behavior.

Provide or suggest opportunities to teach.

◆ Allow postdocs, or in some cases, advanced graduate students, to occasionally give a lecture—either by taking over one of your class sessions and modifying the lecture you might have given, or giving a lecture in their own areas of interest or specialty. You would have to be sure that the lecture complements the course. Give the postdocs or graduate students constructive criticism on their teaching style and presentation of content.

◆ Make other teaching opportunities available. For example, encourage your graduate students or postdocs to go to a local high school and give a presentation, or invite high school students to your lab and allow the grad students or postdocs to answer questions and prepare presentations of the research in your lab.

◆ Encourage postdocs to become adjunct professors at community colleges, to teach summer-school courses, or to teach a session at your institution's "mini-med school," a program for public education that exists on many campuses.

◆ Arrange to have your graduate students and postdocs mentor high school science teachers in a public or private school in your community. Since high school teachers often use active-learning strategies, they might give your postdocs some valuable teaching tips in return for gaining a better understanding of contemporary science content from your postdocs.

◆ Create an education group that meets monthly or quarterly in your lab as a resource for postdocs and graduate students looking for more opportunities to become involved in teaching.

Creating a Learning Environment in Your Lab

In a very real sense, your laboratory is also a classroom—one in which the scientific process often results in something new, exciting, or unexpected. In the lab, as in the classroom, you will want to avoid lecturing and giving students answers too quickly and, instead, emphasize questions and encourage reflection. You can create a culture of learning in your lab for all the students—from postdocs to undergraduates—by using active-learning strategies and by encouraging members of your lab group to learn from each other. Try not to turn away anyone who is asking a question—even if you are in the middle of an experiment. Here are some other ideas to encourage active learning in the lab:

Start a journal club. It's a great way to examine current literature and to let students know there are many questions left to be answered. Ask a postdoc or grad student to select an original peer-reviewed journal article, distribute it in advance to the group, prepare an introduction to the paper, and provide any relevant or background information. If you have a large group, lab members can break up into smaller groups to discuss research-related issues (How good are the data? Should more experiments have been done?), reconvene, and share their thoughts with the group as a whole. While your students are learning about experimental design and other research issues, they will also be learning to collaborate and communicate. Ideally, journal club should be held on a weekly basis, but if that's not possible, one good way to keep everyone up on current literature is to ask each member of the group to present briefly the abstract of at least one paper at the beginning of weekly lab meetings.

Start a monthly film club. Bring popcorn and invite your laboratory group to watch a science-related film such as the 1987 movie, "The Race for the Double Helix," which depicts the events leading to the 1953 discovery of the structure of the DNA molecule. Ask questions that stimulate thinking about a range of science issues. For more film ideas, go to the National Institutes of Health (NIH) "Science in the Cinema" site at *http://science.education.nih.gov/cinema*, or to the NIH site on historical video collections, administered by the National Library of Medicine, at *http://www.nlm.nih.gov/hmd/collections/films*.

More advice on creating a culture of teaching in your lab can be found in chapter 5, "Mentoring and Being Mentored."

> *When students come to you with research results, let them explain their data before you tell them what it means. Then you can nod appreciatively and say, "Well, could be, or have you thought of…?" Students who have put in hard work on an experiment deserve—and need, for their own professional development—the chance to interpret and communicate their data.*
>
> —Thomas Cech, HHMI

PROFESSIONAL CONSIDERATIONS

Balancing research, teaching, and service is not easy, and requires the time management skills noted in other chapters of *Making the Right Moves*. At a research university, most tenure requirements generally give greater weight to research and publications than to teaching. But that situation is changing, as an increasing number of colleges and universities begin to embrace the concept of the scholar-teacher in promotion and tenure decisions.

However, as a practical matter, particularly in the pretenure years of your career, you will want to teach effectively while minimizing the time spent on it and maximizing the recognition you will get.

Time Management

The amount of time you devote to developing a course or teaching it will depend in part on what priority your institution places on teaching. If your institution makes research its top priority, keep in mind that; while you will want to be the best teacher you can in the time allowed, you should not permit your teaching obligations to undercut your commitment to research. Volunteer to teach the courses your department particularly needs but are not as difficult to teach—that way you can legitimately say, "Sorry, I am already committed" when you are asked to teach a course that would be more time-consuming to develop or teach. For example, you may choose to teach a graduate class or seminar in your research area, or use a simplification of your research problem as a project for an undergraduate class. Or you may teach a course without a lab or a class with fewer students. Regardless of the course you teach, here are some tips for making the most of your time.

Borrow, adapt, and recycle.

◆ Teach the same course several times, so that you are making adjustments to it rather than starting from scratch every year.

◆ Teach a course previously taught by someone who is willing to lend you copies of his or her notes, exams, and homework assignments.

◆ Borrow or adapt high-quality curricula that are already available. For example, the Massachusetts Institute of Technology is gradually making available on the Internet the primary materials for nearly all of its 2,000 courses through its OpenCourseWare Initiative (*http://ocw.mit.edu*). Currently, more than 900 courses, such as experimental biology, are available. These materials include lecture notes, syllabi, problem sets, and exams, which you can use to prepare your own classes.

Know yourself.

◆ Consider your personal rhythms. Choose a class that does not disrupt your day. For example, you could teach two back-to-back classes or schedule days without classes so you can find time for your research.

◆ Set realistic limits on class preparation and don't be a perfectionist.

Question: Is it possible to ask for a reduced teaching load when I negotiate the terms for a faculty position?

Answer: It is certainly possible, but your chances of negotiating a reduced load will likely be better at a university that stresses research productivity than at a liberal arts college that puts its chief emphasis on teaching. Even at a research university, however, this is not easy to do. A new faculty member may be given some free time to write grant proposals, especially if the time between the decision about the appointment and the arrival of the new faculty member was brief. If you are successful in obtaining a reduced teaching load during the job negotiations it is important to get it in writing. It might be easier to negotiate specific courses than fewer courses.

Even if you cannot reduce the number of hours, perhaps you may be able to stack your teaching load so that you teach all classes in one semester and arrange to have a term with no teaching. You might also ask to teach multiple sections of the same course to reduce your preparation time, and request graduate assistants to help you grade exams. At the very least, you should try to clarify your teaching load: How many classes will you have each term? What are typical enrollments in each class? How much time will you be expected to spend advising students or supervising theses or dissertations? Does supervising undergraduate research count as teaching? How much credit do you receive for teaching the lab sections of a course? Armed with that knowledge, you might be able to make trade-offs that help you manage your teaching load more effectively.

The Teaching Portfolio

You want to make sure that your teaching successes are favorably considered as part of your tenure review. One way to do this is to develop a teaching portfolio. This document is an important asset not only for your career but also for your own professional development. Compiling your portfolio will force you to reflect on your teaching so you can continue to analyze and improve it.

While there are many ways to compile a teaching portfolio and many items you can include, typical portfolios include a personal statement about your teaching philosophy, evidence of your teaching, and supporting materials. Unlike your scientific curriculum vitae (CV), which lists all publications you have ever written, the teaching portfolio is more selective and has been compared with an artist's portfolio—a sampling of the breadth and depth of your work (see box "Sample Teaching Portfolio" on page 236).

Becoming a good teacher may seem like a lot of work with little reward, but remember that your research and teaching careers can work hand-in-hand. Your research can inform your teaching, and your teaching can inform your research. Learning to be an effective teacher is worth the time and effort. Not only will you be instrumental in inspiring and educating a new generation of scientists, but you will also enhance your own skills, confidence, and creativity. Remember, too, that teaching can be a stabilizing force in your life, especially if your research becomes discouraging or you lose ground in the laboratory. The time you spend in preparing an effective course with active-learning activities can give great personal rewards, as your students demonstrate their knowledge on a test or tell you that, for the first time, they really understand DNA structure and function. And, since teaching is one of the three pillars on which decisions about tenure and certain grants are made, your success in teaching and course design will only improve your chances of having a long, productive, and well-funded career in academia.

Sample Teaching Portfolio

A teaching portfolio includes these items:

◆ *Personal material:* A short statement of your teaching philosophy, a broader statement of your teaching responsibilities, representative course syllabi, and steps you have taken to enhance your teaching skills or background knowledge

◆ *Materials from others:* Student and course evaluation data from present and former classes, statements from colleagues who have observed your classroom teaching, statements from TAs you have supervised, and any honors or other recognition you received for teaching

◆ *Products of teaching:* Student scores on class, departmental, and national certification exams, samples of student work, and testimonials from alumni or employers of former students

While the list might seem overwhelming at first and could take years to develop to the fullest, it is manageable if you take it in steps. The most important thing is to start collecting and organizing data related to your teaching philosophy and accomplishments and to start compiling those materials in a box, a loose-leaf notebook, or another format that can easily be updated and supplemented. (For a good introduction to teaching portfolios, go to *The Teaching Portfolio,* by Hannelore B. Rodriquez-Farrar, Harriet W. Sheridan Center, Brown University, at *http://www.brown.edu/Administration/Sheridan_Center/publications/ teacport.html*, or *Preparing a Teaching Portfolio, a Guidebook,* Center for Teaching Effectiveness, University of Texas at Austin, *http://www.utexas.edu/academic/cte/teachfolio.html*.)

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APPENDIX 1: EXAMPLES OF ACTIVE ASSESSMENTS FOR LARGE LECTURES

The goal of active assessments is to provide feedback about learning to both instructors and students. While instructors may choose to grade these assessments, they are also helpful to give context to the topic they are lecturing about, motivate students to participate in and take responsibility for their own learning, and offer them the opportunity to think critically. Many of the active assessments work best when students work together in pairs or groups of three to five, but some work best as individual activities. In addition, the active assessments can help instructors determine what works best for their own teaching style.

Brainstorm. Brainstorming is possibly the fastest and easiest way to incorporate active learning into a large lecture, and it is a quick way for students to assess what they already do or don't know.

Example: *What does a plant need to survive?* This activity works well for any organism and drives home the point that students already know more than they think they do. The list can go on and on, if students start to list individual minerals and other components. But no matter what they come up with for the brainstorm list, it can always be separated into two categories. For example, abiotic versus biotic factors or environmental versus genetic requirements. These categories can then be used as the basis for a subsequent lecture or laboratory exercise.

Pre/posttest. Pre/posttest is another simple way to help students gauge what they've learned. If their answers don't change over time, it tells the instructor that something is amiss with the learning, the teaching, or the assessment.

Example: *Describe two ways a bacterium could harm a plant.* Have students write down their answers during the lecture, and then finish the class and have them answer again (posttest). Have students compare their two answers.

Think-pair-share. Think-pair-share activities work well to encourage group learning. Students answer a question individually, then share their answers with other students nearby and discuss which answers make the most sense. After 35 minutes, some of the groups report their conclusions. An optional step can be added to include experimental results. It's helpful to compare student answers from before and after discussion. This activity works well with electronic audience response systems, or "clickers."

Example: *Experimental design consists of three treatments of radish seed sets:*
> *(1) light, no water*
> *(2) light, water*
> *(3) no light, water*

Which set of plants will have the lowest dry weight after 3 days?

First, students answer the question individually for one to two minutes. Next, they work as groups to share and discuss their answers and come to consensus. After

three to five minutes of discussion, the students answer the question again. Finally, show the actual experimental results: *Treatment #3 has lowest biomass.*

It's important that students discuss the experimental results with their group so they can figure out themselves that the result makes sense only if they understand that respiration, in addition to photosynthesis, occurs in plant cells. (This example is used with permission from Ebert-May, et al. 2003)

One-minute paper. One-minute papers are a great way to capture what students are thinking. For example, when used at the end of class, the instructor can gauge what students have learned by asking them to list the three most important things they learned that day in class. At the beginning of class, the instructor can gauge what students retained from the previous lecture or a reading assignment.

Example: At the end of a lecture about the structure of DNA, have students read about the structure of DNA online (*http://www.dnai.org/a/index.html*) in a text-book chapter. Students are expected to write a one-minute paper at the beginning of the next class period about DNA replication: *What about the structure of DNA suggests a mechanism for replication?*

Predict-observe-explain. A predict-observe-explain activity is a simplified version of the scientific method in which students make *predictions* based on a hypothesis, observe results, and explain how the predictions and observations relate to each other. In this activity, students need to identify what they don't understand about bacterial growth.

Example: *Microbes are everywhere. Touch an agar medium with your fingers and predict what you'll see in a week. A week later, observe what grew on the medium, describe whether the observations support the hypothesis and match the predictions, and explain why.*

Alternatively, the instructor provides data for an experiment that students explain.

Concept map. Concept maps can be a powerful tool for students to assess their own learning because they need to create a visual representation and verbal explanation for complex concepts.

Example: *Explain how these terms relate to each other by arranging them in a logical order: Protein, tRNA, DNA, transcription, amino acid, translation, replication, gene expression, promoter, nucleotide.*

What's wrong with this statement? One of the most powerful learning tools is to have students explain why a statement is incorrect.

Example: *I don't want to be eating any viruses or bacteria in my food, so I won't eat genetically modified plants.*

Cases. Cases offer the opportunity for rich exploration into many concepts in the context of a real-world scenario.

Example: *A patient had itchy, goopy eyes, so he went to the doctor. The doctor diagnosed the irritation as conjunctivitis and prescribed antibiotics. Symptoms cleared up within a few days. The infection reoccurred two weeks later. The patient called the doctor, and she advised taking antibiotics again. The patient washed his sheets in hot water, washed his hands incessantly, cleaned his keyboard with soap and water, and bleached the washcloths he used to wash his face. The infection reoccurred again two weeks later. The patient called the doctor, who advised taking antibiotics again.*

> *(1) Write three hypotheses to explain why the infection reoccurred.*

> *(2) What should the patient do? Should he take the doctor's advice? Describe any assumptions you make and justify your recommendation with biological reasons and principles.*

Source: Handelsman, Jo, Sarah Miller Lauffer, and Christine Pfund. *Scientific Teaching: A Guide to Transforming Undergraduate Biology Education*, Greenwood Village, CO: Roberts and Company Publishers, in press.

APPENDIX 2: BLOOM'S TAXONOMY

Bloom's Taxonomy is a well-known way to classify and test cognitive abilities. Developed by educational psychologist Benjamin Bloom and four colleagues, the system is based on the premise that students engage in distinct behaviors that are central to the learning process. Bloom classified the behaviors into six categories that become increasingly more complex as they ascend from knowledge to evaluation.

Knowledge. Knowledge questions require students to recognize or recall pieces of either concrete or abstract information, such as concepts, dates, definitions, events, facts, formulae, ideas, terms, persons, and places. Typical exam wording includes choose, define, find, identify, label, list, match, name, recall, select, show, state, translate, true/false, who, what, where, when, why, and which.

Example: *Which of the following is not an event that occurs during the first division of meiosis?*
   1. Replication of DNA
   2. Pairing of homologous chromosomes
   3. Formation of haploid chromosome complements
   4. Crossing over
   5. Separation of sister chromatids

Comprehension. Comprehension questions ask students to demonstrate their understanding of the subject matter. Typical exam wording includes arrange, classify, compare, compute, contrast, demonstrate, describe, discuss, distinguish, explain, extrapolate, group, interpret, illustrate, order, outline, paraphrase, provide example of, relate, rephrase, show, summarize, and translate.

Example: *How are proteins destined for export from a cell typically modified prior to secretion?*

Application. Application questions challenge students to use and apply abstractions (e.g., ideas, concepts, principles, models, methods, theories, and formulae) to explain concrete situations or solve problems. Typical exam wording includes apply, build, calculate, choose, classify, demonstrate, experiment with, how, interpret, make use of, organize, relate, solve, and utilize.

Example: *Given what you know about the life cycle of a virus, what effects would you predict antiviral drugs to have on viruses?*

Analysis. Analysis questions ask students to break down a whole into identifiable parts so that organizational structures, patterns, and relationships between the parts can be made explicit. Typical exam wording includes analyze (e.g., a case study), categorize, classify, compare, contrast, differentiate, discover, dissect, distinguish, divide, examine, inspect, recognize, relate, separate, solve, survey, and test.

Example: *What distinguishes the replication processes of RNA and DNA viruses?*

Synthesis. Synthesis questions ask students to recognize relationships between parts, combine and organize components, and create a new whole. Typical exam wording includes build, combine, compile, compose, create, construct, design, develop, estimate, formulate, imagine, improve, invent, modify, order, predict, propose, reconstruct, solve, summarize, and theorize.

Example: *Propose a way in which viruses could be used to treat a human disease.*

Evaluation. Evaluation questions challenge students to use certain criteria in order to appraise the degree to which a concept (e.g., ideas, solutions, work, theory) is satisfying, effective, or valid. Typical exam wording includes appraise, assess, choose, conclude, critique, decide, defend, determine, dispute, estimate, evaluate, judge, justify, measure, opinion, prioritize, prove, rate, recommend, select, and support.

Example: *Should the classification of living things be based on their genetic similarities or their morphology/physiology? What are the reasons for your choice?*

Source: Allen, Deborah, and Kimberley Tanner. *Cell Biology Education* 1:63 (Fall 2002); adapted from Bloom, Benjamin S., ed. *Taxonomy of Educational Objectives: Handbook 1,* Cognitive Domain. New York, NY: McKay, 1956.

Index

A

absences, prolonged, 65
abstracts
    for grant applications, 165
    for research papers, 179, 180
academic health center, 28–29
accommodating, in managing conflicts, 70
accomplishment, measures of, 100
active assessments, for large lectures, 223, 242–244
active learning
    in the classroom, 216–220
    defining, 216
    in the lab, 220–221, 233
    at a medical school, 221–222
    principles of, 215–221
    reviewing with teaching assistants, 231
    setting the stage for, 220
    in small and large settings, 216
    tools of, 216
activities, in project management, 129, 131
activities plan, 131, 141
administrative budget supplement, 169
administrative structure, of medical school, 29
administrators, getting acquainted with, 30
admissions committees, 36
advance preparation, for job interviews, 11–12
advertising for staff, 79
adviser
    versus mentor, 99–100
    relationship with, 11
American Association of University Professors
    (AAUP), 17, 20
American Chemical Society, salary survey, 20
analysis questions, 245
animal studies, requirements for, 32
application questions, 245
archival software, for storing data, 152
archiving data, 148, 150, 152
assertiveness, in managing conflict, 70
assessments
    by the instructor, 216
    of student learning, 223–225
Association of American Medical Colleges, salary
    survey, 20
assumptions, of a statement of work, 128
"at will" appointments, 18
audience, for a project, 128–129
authority, delegating, 56–57
authorship, 9. *See also* journals; papers
    and collaborations, 206–207
    first, 179–180
    guidelines for, 65
    and postdoc qualifications, 82
    setting expectations for, 65
    avoiding, managing conflicts, 70

B

Bayh-Dole Act, 33, 187
behavior
    modifying for leadership development, 51
    rules for, 63–67
benchwork, planning, 131–132
benefits, employee, 20
best practices, in consulting agreements, 197–198
billable hours, for physician-scientists, 21
Blackboard, course management systems from, 229
Blanchard and Hershey model, 55–56
bloodborne pathogens, requirements for using, 32
Bloom's Taxonomy, 224, 225, 245–246
board of trustees, 26
bottlenecks, identifying in project management, 132
budgeting, 32, 168–170

C

Career Awards in Biomedical Sciences (CABS), 19
career development, for junior faculty, 213
career summary, for job interview, 9
career trajectory, for tenure-track physician-
    scientists, 45
case-based learning, 222
case-based problems, 218–219
Center for Scientific Review (CSR), 154
chalk talk, 15
championing a project, 134
chancellor, university, 26
chemicals, requirements for using, 32
chief executive officers, of academic health
    centers, 29
childcare arrangements, 122–123
choices, time management, 115
citation index, 176
classroom, active learning in, 216–220
classroom clickers. *See* clickers
classroom time, controlling, 120
clickers, 219, 223, 242
clinical duties, of tenure-track physician-scientists, 45
clinical settings, research in. *See* physician-scientists
clinical time, "buying out" of, 21
coaching behavior, 56
collaborating, in managing conflicts, 70–71
collaborations, 201–210
    agreements, 204–205
    assessing opportunities for, 202–203
    failure of, 209
    ingredients of successful, 205–207
    international, 208–209
    resources, 210
    setting up, 2, 203–205
    special challenges for beginning
    investigator, 207–208
    and sponsored research agreements, 196
    and technology transfer issues, 205–207
    and tenure issues, 203, 207
    varieties of, 201
collaborator, personal qualities of a good, 207

Writing a Letter of Recommendation

Making the Right Moves:
A Practical Guide to Scientific Management for Postdocs and New Faculty

second edition

Making the Right Moves: A Practical Guide to Scientific Management for Postdocs and New Faculty, second edition

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This publication is available online at *http://www.hhmi.org/labmanagement*.

WRITING A LETTER OF RECOMMENDATION

As a beginning independent investigator, chances are you will soon have to write a letter of recommendation on behalf of a student, a postdoc, or even a colleague. Your job as letter writer will be to describe the candidate's strengths and weaknesses as they relate to the position or program in a way that is both thoughtful and personal. A letter that falls short of this goal will be of little value to those evaluating applications and will not help the candidate get what he or she is after. So, it pays to put in the necessary effort and time to write a "good" letter. This chapter provides insights and advice from experienced investigators on how to do so. It is not meant to be prescriptive but rather to offer some suggestions from which you can pick and choose.

BEING ASKED TO WRITE A LETTER

Letters of recommendation are ubiquitous in an academic research career. If you teach one or more senior-level undergraduate courses or have undergraduate students in your laboratory, you might have to write dozens of letters a year as students become graduate-school bound or look for employment. If you do not teach undergraduates and have primarily graduate students and postdocs in your lab, you will have significantly fewer letters to write—maybe for only one or two people each year.

In addition to the people in your own lab, graduate students and postdocs in your department may ask you to write letters for them when they apply for fellowships or seek new positions. Colleagues might also ask you to write letters of recommendation on their behalf for various promotions or awards, but that may not happen too often until you are more established.

For Whom Should You Write?

As a mentor, you have an obligation to support students and postdocs in your lab in their job search and to help them find a good match for their abilities and aspirations. If they ask you to write a recommendation letter, it is customary to support them in this way. The best thing to do is to sit down with them and discuss their plans *before* they start applying for jobs. If their career goals are unrealistic, talk about what they need to do to become more competitive or help steer them

in a different direction. If you do end up writing a letter for someone in your lab for a job you don't think is a good fit, there are ways to put a positive spin on the negative (see page 6, "Writing a 'Not-So-Enthusiastic' Letter"). If people who are not part of your lab ask you to write a letter for them, it is up to you to decide whether to do so.

Reasons to Turn Someone Down

You should write a letter of recommendation only if you can honestly write a supportive letter for someone for a given position. After all, a letter of recommendation is supposed to be a tool for helping people obtain what they are after. If you don't know the candidate well enough to write a good letter, let the person know. He or she will probably ask someone else.

If you do know the candidate well but have some reservations, let the person know about your concerns, and leave it up to him or her to decide whether you should still write the letter.

PREPARATION

Read Some Sample Letters

If you have never written a letter of recommendation before, read a stack of reference letters to see what works and what doesn't. Most faculty have access to graduate student applications and the letters submitted. Junior faculty can also ask their more experienced colleagues to share "sample" letters they have written or have received from applicants (blocking out names and other personal information). The resource section of this chapter provides links to sample letters.

Collect Information

Once you know what a letter of recommendation looks like, make sure you find out as much as possible about the candidate for whom you are writing. One of the worst things you can do is to write a letter that is too generic.

TIP: When reading a sample recommendation letter, try to put yourself in the position of whoever is going to read it, keeping in mind that you could be reading the letter late at night or when you are pressed for time. Ask yourself which letters stand out and then use them as models for your own letters.

Ask for the following information:

◆ For people in your lab—you probably already have a current curriculum vitae (CV), but also ask for as complete a description as possible of the position or program for which the person is applying.

◆ For people who are not in your lab—ask for a current CV that includes the dates and locations of their training and a list of publications as well as copies of any papers that are in press or that have been submitted.

◆ For people who were in your lab but have since moved on—ask for a written summary of their current work, future plans, and why they are interested in the position for which you are writing the letter.

◆ For students who are not in your lab or department but who were in one of the classes you taught—ask for transcripts and check your class records.

Many reference writers find it helpful to meet with the person who has requested the letter of recommendation. In such a meeting you can learn about the person's long-term career goals and how his or her current research and other activities relate to these goals. Ask about the programs or positions for which letters are being requested and what the individual's preference is and why. You should also discuss the candidate's strengths and weaknesses as they relate to these positions.

If you cannot have a face-to-face meeting, ask the candidate for a detailed written description of these issues.

> **TIP:** Don't ask the candidate to write a draft of the letter for you. Most heads of labs say this rarely saves time and sometimes leads to a weaker letter. It is better for the candidate to provide you with all the necessary information, from which you can then pick and choose as you write your letter.

Allot Sufficient Time to Write and Send the Letter

Once you have gathered the data and marked the deadline on your calendar, make sure you set aside enough time to write the letter. It can take one to two hours, sometimes longer, to craft a well-written letter for one individual. (It takes less time to tweak this initial letter for different programs or positions the same individual has applied to.)

The candidate should give you clear instructions on how and where to send the letter. Some letters have to be submitted online, some e-mailed, and others sent by snail mail.

WHAT THE LETTER SHOULD SAY

Keep the following pointers in mind when you craft your letter.

Introduce Yourself and the Candidate

Begin the letter by describing how you know the candidate. Briefly state your own qualifications so that people who don't know you can decide whether to

trust your judgment. But don't go overboard and make the letter about yourself!

For example, "During my years of training as a postdoc and now as a faculty member, I have worked with and personally trained more than xx graduate students in laboratories at the University of Michigan, Harvard Medical School, and, currently, at Emory University. In my opinion, candidate x is among the top 5 percent of the graduate students I have known." (You may want to include students you trained as a postdoc, if you have not yet had many students in your own lab.)

Present the Candidate Truthfully but Positively

Devote several paragraphs to discussing the candidate's scientific work and personality, following the suggestions below.

Be specific. Give meaningful examples of achievements and provide stories or anecdotes that illustrate the candidate's strengths. Don't just praise by using generalities (such as "quick learner"), but say what the candidate did to give you that impression. These details will show you have a strong relationship and also bring the candidate alive on the page. If the candidate works in your laboratory, make sure the letter talks about his or her specific contributions to the lab's research.

◆ "Student x is the first person to successfully master in vivo imaging in my laboratory and did all the trouble-shooting calibration and testing completely independently."

◆ "Student x is the first student in my lab to have a first-author *Cell* paper. She contributed data for five of the figures and made an important intellectual contribution to the experimental design and to writing the discussion."

◆ "Candidate x's research was submitted as an abstract and was accepted for a podium presentation at the American Association for Cancer Research national meeting earlier this year. Although she is an undergraduate student, I treated candidate x in the same manner I would treat an experienced graduate student by having her prepare and present the talk independently. At the meeting, she presented the work and answered all the questions from the audience in a clear and professional manner. After the talk several scientists came up to express how impressed they were with the presentation."

> **TIP:** Don't make the letter too short, because it will give the reader a negative impression of the candidate. Letters of recommendation should be between one and two pages.

You don't just have to describe the candidate as he or she is right now—you can discuss the development the person has undergone.

- ◆ "When candidate x came to the lab he showed promise but was not able to plan experiments effectively. Through his own hard work he has acquired this skill and has become an excellent scientist."

Quantify and compare. Find a way to quantify the candidate's abilities, especially with respect to other scientists who have achieved success in the field and who the letter reader might know. Many letter writers rank the applicants according to their own measure of what makes a good researcher, graduate student, or technician. Depending on the position, most people rank candidates according to a combination of research strength, leadership skills, writing ability, oral communication, teaching ability, and collegiality.

- ◆ "There are currently 17 graduate students in our department and I rank candidate x as 4/17. Her bench skills are the best I have ever had in my own lab, but she still needs to develop better communication skills."

Address the requirements of the position. Make sure the letter discusses the most important skills and personality traits needed for success in the job.

- ◆ "I understand that you are looking for a person who will be able to establish a program to study nuclear structure and architecture using imaging technologies. Candidate x has performed similar studies using fluorescent imaging in living cells. Her mastery of these experimental techniques is demonstrated by her recent first-author publications in *Journal of Cell Biology* and *Nature Cell Biology*."

If you are writing a letter for someone applying for a position as a physician-scientist, you should comment on his or her bedside manner. For example, if you are a chief of service, comment on the candidate's clinical skills and personality and how he or she interacts with patients.

Talk about personal attributes. Does the candidate work well with others? Has she or he taught other people in the lab? Has the candidate shown motivation

> *We look for more than research accomplishments—comments on creativity, originality, independence, and leadership are usually not overhyped and mentioned specifically in letters of the very best candidates.*
>
> —Suzanne Pfeffer, Stanford University School of Medicine

and commitment in her or his work? Often these descriptions are what distinguish a good letter of recommendation from a great one.

Make it memorable. Put something in the letter that the reader will remember, such as an unusual anecdote, or use an unusual term to describe the candidate. This will help the application stand out from all the others.

Beware of what you leave out. Remember that what is *not* said in a reference letter can be just as important as what *is* said. If you don't mention a candidate's leadership skills or his or her ability to work well with others, for example, the letter reader will wonder why.

> **TIP:** A final statement summarizing your enthusiasm for the candidate is often very useful in focusing the reader's attention on your conclusions and your excitement for candidate.

Express Your Willingness to Help Further

Conclude the letter by offering to be contacted should the reader need more information or have questions. Make sure to provide your phone number and perhaps the best times to reach you.

WRITING A "NOT-SO-ENTHUSIASTIC" LETTER

If you write a letter for someone about whom you have some concerns—for example, the person lacks strong leadership skills or isn't highly motivated—you can still write a generally positive letter, leaving out a mention of these qualities. This omission will send a signal to readers who will be looking for these details. A short letter will also signal that you are not overly enthusiastic about the person for this particular position. If the reviewers are interested in the candidate, they may call you for more details and you will then have the opportunity to explain your reservations.

You can also mention negative things by putting a positive spin on them. For example, if someone has not published much you can say "candidate x has taken a long time to get experiments going but now has several papers in press and I think they will make an important contribution to the field."

> **TIP:** If the candidate is a good scientist but better suited, say, for a faculty position at some schools and not others, some researchers handwrite that perception on top of the standard letter to those "other" schools. This way they still help the candidate obtain a faculty job without harming their reputation for good judgment.

Yet another way to make a criticism sound less damaging is to say something like "when candidate x came to the lab his writing skills were poorly developed, but he has worked hard to improve them and has made great strides in that direction."

Terms like "room for improvement," "has worked hard to," and "made great progress in" are useful and help turn a negative into a positive.

WHAT THE LETTER SHOULD *NOT* SAY

Avoid Irrelevant Information

Letters should not mention anything that is irrelevant to doing the job, such as ethnicity, age, hobbies, marital status, and so on. A writer might want to say things like "candidate x understands how important it is to have a lab team that functions well and has organized several social events for the lab that have helped make it both productive and happy" to show that the person is social and easy to get along with. That is something that might be important to the job. In some cases, personal information may illustrate the ability to persevere and overcome adversity, qualities that are helpful in research.

But statements like "candidate x is very religious and has demonstrated religious fervor uncommon for someone his age" has no bearing on whether someone will do well in graduate school or in a job.

Personal information may be revealed if it helps explain a weakness in someone's application. For example, sometimes there are acceptable circumstances for a gap in someone's publication record—perhaps a medical condition or a family situation kept that person out of the lab for a period of time. It is okay to explain that in the letter of recommendation but only after discussing it with the candidate.

Another example of a personal situation that might warrant discussion would be a case in which a postdoc is not able to ask his or her advisor for a letter of recommendation because of a bad relationship. If you, as the letter writer, know about this situation, you might want to mention in the letter that "there was a personality conflict but it does not reflect on the ability of the candidate to do the job."

Don't Say Anything That Is Not True

Obviously, all information in a letter of recommendation should be, to the best of your knowledge, accurate. But sometimes letter writers stretch the truth to make a candidate sound better than he or she really is, thinking it is helpful.

This strategy can backfire. According to a member of a recent search committee, the head of one lab wrote letters for three applicants from his lab, and in each letter he stated that the applicant was "the best postdoc ever in my lab." Most researchers say that the most effective letters they receive include some weakness to balance the strengths.

> *You don't help the candidate by overhyping them. You should write strongly and specifically about someone who is really excellent (say how and why they are special). But it's okay to write a balanced letter, even for the top folks.*
>
> —Suzanne Pfeffer, Stanford University School of Medicine

BE AWARE OF GENDER BIAS

Choose Your Words Wisely

Two studies have shown that there may be some differences in the choice of words used in letters for male and female scientists. Both Trix and Psenka (2003) and Schmader, Whitehead, and Wysocki (2007) found that letters for women did not contain as many "standout" adjectives—words like "superb," "outstanding," and "excellent"—as did letters for men. In addition, Trix and Psenka found that letters for women had more doubt-raising statements, including negative or unexplained comments.

> *If you say that Chris works well in a team—that might be interpreted differently depending on whether Chris is male or female. Exactly the same language can convey different messages because of people's antecedent beliefs about gender differences. The reader might infer that Chris the man is a good team leader or someone who can work well with a team even when he isn't a leader of it. Chris the woman, in contrast, may look as if she can't or doesn't lead. For both men and women, then, it is good to be explicit that the person is both a good team leader and can work collaboratively."*
>
> —Virginia Valian, Hunter College

Test for Possible Bias

Although it is not clear what the effect of the choice of words is, it seems plausible that the words you use will affect the reader's perception of the candidate—the stronger the words, the stronger the candidate. In an exercise conducted at

the 2005 BWF-HHMI Course in Laboratory Management, course participants were asked to read two letters written by the same professor for two postdocs in his lab, one male and one female (see appendix), with similar qualifications and achievements. The professor used more specific and descriptive language, as well as more standout adjectives, for the male candidate than for the female candidate (see summary document, appendix). As a result, course participants overwhelmingly gave the male postdoc a higher ranking than the female postdoc.

> **TIP:** Write a letter of recommendation for any candidate, male or female, and then switch all the pronouns to the opposite gender. Read the letter over and ask yourself: Does it sound odd? If it does, you should probably change the terms used.

ASKING SOMEONE TO WRITE A LETTER FOR *YOU*

Many letter writers also need letters written on their behalf at some point in their careers. If you are asking someone to write a letter of recommendation for you, make sure you follow these guidelines:

◆ Plan way ahead. If you want good letters of recommendation, you need to plan several years in advance. It is important to have established personal relationships with potential writers early on in your career. The best letters are the ones that come from people who say "I have known this person for x years."

Try to establish strong relationships with at least half a dozen people, some of whom should be well known in your field. People who read the recommendation letter are more likely to care about the opinion of someone who has a good reputation in the field.

◆ Be specific. When you ask someone for a recommendation letter, be very specific about what you want.

◆ Prepare the writers. Once your reference has agreed to write a recommendation letter for you, a good strategy is to give the person a memo that describes the job or jobs to which you are applying and the key skills or attributes and other aspects of your background that make you well suited for the job.

Other documents you should provide, depending on how well the person writing the letter knows you, are a CV, any papers published and in press, and copies of academic transcripts. You should also provide parts of the application that you have had to write yourself, such as a personal essay of your career goals or a statement of your teaching philosophy. The letter writer can speak to these items if he or she has the complete application.

You may be asked to write a draft of the letter. As mentioned on page 1, many heads of laboratories say this is not a good idea. However, if you are asked to do it, do it!

Make sure you provide the writers with the instructions for submitting the letter and the deadline. If letters are to be mailed, give them postage-paid addressed envelopes. Also provide any forms that are supposed to be submitted with the letter. (Make sure to complete as much information as possible on those forms so that the letter writer does not have to do it.)

◆ Meet with the writers. If possible, meet with the letter writer and go through all the information you are providing. If the writer is in a different location you can talk to him or her by phone.

◆ Don't miss the deadline. Give references plenty of time to accomplish their tasks. Ideally, approach them with the request at least three weeks before the letter is due. Once you have provided all the information, remind them of the deadline and check back periodically. Reminders will not be resented.

◆ Don't argue. If someone says that they do not know you well enough or don't have the time, don't try to convince them otherwise.

TIP: If you get the position, make sure that the reference writer knows it and then thank the person formally with a note. Who knows, there may come a time when you will want to ask this person for a recommendation letter again!

Like many other tasks new faculty have to perform, writing letters of recommendation becomes easier with practice. But regardless of how many letters you write, each letter requires time and effort. Take the job seriously. Although a poorly written letter is not going to sink a career, a well-written one can make an application stand out from all the others.

RESOURCES

The Survival Skills and Ethics Program at the University of Pittsburgh provides several useful resources for graduate students, postdocs, and new faculty, including a sample letter of recommendation.
See *http://www.skillsandethics.org*   .

Cynthia Verba, director of fellowships for the Graduate School of Arts and Sciences at Harvard University, has written a useful article with several sample letters for teaching fellows (or tutors) writing letters of recommendation for their students at
http://isites.harvard.edu/fs/html/icb.topic58474/Verba-recs.html.

Michel Ernst at the Massachusetts Institute of Technology has written several tips as well as a book for writing letters of recommendation at
http://people.csail.mit.edu/mernst/advice/write-recommendation.html.

Ira Mellman, former cell biology department head at Yale University and currently a scientist at Genentech, wrote two articles for the *American Society of Cell Biology Newsletter*:
"How to write an effective letter of recommendation"
http://www.ascb.org/files/0505wicb.pdf

and

"How to read a letter of recommendation"
http://www.ascb.org/files/0507wicb.pdf.

The Social Psychology Network provides suggestions and pointers
for students on how to go about obtaining a letter of recommendation at
http://www.socialpsychology.org/rectips.htm.

For information about how gender affects science careers, including reference letters, see Virginia Valian's website at *http://www.hunter.cuny.edu/gendertutorial/* and
http://www.hunter.cuny.edu/genderequity/.

Two studies have looked at how gender bias affects how letters of recommendation are written:

Trix, Frances, and Carolyn Psenka. "Exploring the Color of Glass: Letters of Recommendation for Female and Male Medical Faculty." *Discourse & Society* 14(2):191–220 (2003).

Schmader, Toni, Jessica Whitehead, and Vicki H. Wysocki. A Linguistic Comparison of Letters of Recommendation for Male and Female Chemistry and Biochemistry Job Applicants. *Sex Roles* 57:509–514 (2007).

Two articles in the *Chronicle of Higher Education* observe that letters of recommendation are often overhyped and discuss some reasons why that might be:

Schneider, Alison. Why You Can't Trust Letters of Recommendation. *Chronicle of Higher Education* 46(43): (June 30, 2000).

McCloskey, Deidre. The Random Insanity of Letters of Recommendation. *Chronicle of Higher Education* 48(25): (March 1, 2002).

ACKNOWLEDGMENTS

APPENDIX

Recommendation Letters for Dr. Stephen Hoffmann and Dr. Susan Hoffmann

This appendix contains two sample letters of recommendation written for two fictitious postdoctoral fellows from the same lab—the first one for a male post-doc, Dr. Stephen Hoffman, and the second one for a female postdoc, Dr. Susan Hoffman. Both letters were written by the same person, a "Distinguished Professor Corvallis," who used different language to describe the two candidates. The appendix also contains a side-by-side comparison of the terms used to describe the two candidates.

The letters were used in an exercise at the 2005 Course in Scientific Management organized by the Burroughs Wellcome Fund and Howard Hughes Medical Institute conducted by Jo Handelsman, Christine Pfund, Sarah Miller Lauffer, and Christine Pribbenow from the Wisconsin Program for Scientific Teaching. The exercise was meant to illustrate how the language used in a reference letter can give different impressions of two candidates with very similar qualifications. As shown by a number of studies, letter writers tend to use stronger terms for male candidates than for female candidates.

Letter for Stephen Hoffmann

Search and Screen Committee
Department of Bacteriology
University of Cambridge
Boston, MA 01237

Dear Members of the Search Committee,
It is my pleasure to recommend Dr. Stephen Hoffmann for the position of Assistant Professor in your department. Stephen completed his Ph.D. in my lab and is one of the most outstanding researchers to emerge from my lab. I recommend him to you highly.

In my lab Dr. Hoffmann cloned and characterized the *gliD* gene from *Cytophaga johnsoniae*. He made the intriguing discovery that the GliD protein is required for gliding behavior in *Cytophaga* and its human homologue is associated with a highly metastatic form of breast cancer. This observation suggests that there may be common features in bacterial gliding motility and mobility of human tumor cells. Dr. Hoffmann initiated a highly productive collaboration with Professor David Whitely that led to the crystallization and high resolution structure of the GliD protein. Dr. Hoffmann brought that work to fruition in a *PNAS* paper, on which he is the senior author. In addition to the *PNAS* paper, Dr. Hoffmann published three other papers from his thesis, which attest to his hard work, biological insight, and outstanding writing skills. Dr. Hoffmann proved himself an outstanding researcher and valued colleague.

Dr. Hoffmann continued to produce original research as a postdoc in Jim Wooley's lab working on *Bacillus subtilis* development. Once again, Dr. Hoffmann discovered a gene that is found in both prokaryotes and eukaryotes, this time in a search for sporulation genes in *B. subtilis.* He identified a new sporulation gene, designated *spoW*, which has a mammalian homologue that appears to be associated with lymphocyte differentiation and maturation. Although that work is not yet published, it has a bright future. The project was technically challenging, but Dr. Hoffmann has surmounted all of the obstacles and a genetic and biochemical analysis of the *spoW* allele and its product will be ready for publication soon. Given Dr. Hoffmann's past record in publishing research, I have no doubt that this work will be published in a top-tier journal.

Dr. Hoffmann proved himself to be a capable mentor and teacher. He has supervised three undergraduate researchers. He is clearly able to transmit his passion and talent for research to young scientists. Similarly, his classroom teaching was met with rave reviews. Dr. Hoffmann is one of my few colleagues to whom I will entrust my class when I travel. Dr. Hoffmann was also a terrific citizen and a leader in my lab. He handled responsibility well, was resourceful, and took initiative to maintain equipment and ensure that safety standards were met. He took on many of the responsibilities of a faculty member and excelled in everything he did.

In short, I give Stephen my highest recommendation. He is one of my finest colleagues—an outstanding researcher and talented teacher. He has demonstrated an uncanny ability to unmask genes that play parallel roles in bacteria and mammals, and I expect him to be one of the leading researchers in his field. He would be a good catch for any department and I urge you to consider his candidacy seriously.

Sincerely,

Theodore Corvallis
Distinguished University Professor

> Rating
> 1 = not interested in this one
> 2 = keep this one in the pool, but I expect better candidates in the pool
> 3 = very strong candidate, but have a few concerns
> 4 = outstanding candidate; definitely move to next stage
> 5 = superlative candidate; better snatch this one before Stanford does!

Letter for Susan Hoffmann

Search and Screen Committee
Department of Bacteriology
University of Cambridge
Boston, MA 01237

Dear Members of the Search Committee,

It is my pleasure to recommend Dr. Susan Hoffmann for the position of Assistant Professor in your department. Susan was my graduate student and ranks among my very best students. I recommend her to you highly.

As a student, Susan cloned and characterized the *gliD* gene from *Cytophaga johnsoniae.* She made the intriguing discovery that the GliD protein is required for gliding behavior in *Cytophaga* and its human homologue is associated with a highly metastatic form of breast cancer. This observation suggests that there may be features in common between bacterial gliding motility and mobility of human tumor cells. A highly productive collaboration with Professor David Whitely led to the crystallization and high resolution structure of the GliD protein. That work was published in a *PNAS* paper, on which Susan is a coauthor. In addition to the *PNAS* paper, Susan published three other papers from her thesis, which attest to her hard work, biological insight, and outstanding writing skills. Her high productivity as a graduate student is particularly remarkable because she had two children while in graduate school and her husband is a resident in emergency room medicine.

Susan continued her record of excellent work as a postdoctoral student in Jim Wooley's lab working on *Bacillus subtilis* development. Once again, Susan discovered a gene that is found in both prokaryotes and eukaryotes, this time in a search for sporulation genes in *B. subtilis.* She identified a new sporulation gene, designated *spoW*, which has a mammalian homologue that appears to be associated with lymphocyte differentiation and maturation. Susan has been slow to publish this work and therefore has no publications from her three-year postdoctoral study. No doubt her family responsibilities have contributed to this delay.

Susan proved herself an able mentor and a sterling classroom teacher. She has three undergraduate researchers who have all coauthored publications, which is indicative of the excellent mentorship they received from Susan. Similarly, her classroom teaching was met with rave reviews. Of all of my students, I felt the most comfortable asking Susan to cover my classes for me when I was out of town because I knew she would do a great job. Susan was also a cooperative and reliable lab citizen. She handled responsibility well and conscientiously followed through on all that was asked of her to maintain equipment and ensure that safety standards were met.

In short, I give Susan my highest recommendation. She is one of the best students I have seen and is a talented teacher and mentor. She has an uncanny ability to unmask genes that play parallel roles in bacteria and mammals, and I expect her to continue to be as productive and creative as she was as a student in my lab. She would be a good catch for any department and I urge you to consider her candidacy seriously.

Sincerely,

Theodore Corvallis
Distinguished University Professor

Rating
1 = not interested in this one
2 = keep this one in the pool, but I expect better candidates in the pool
3 = very strong candidate, but have a few concerns
4 = outstanding candidate; definitely move to next stage
5 = superlative candidate; better snatch this one before Stanford does!

Side-by-Side Comparison of the Letters

Here is a side-by-side comparison of the terms used in each letter (in each case, the first bullet is how Corvallis describes Stephen Hoffman and the second bullet, in italics, is how he describes Susan Hoffmann):

First paragraph:

◆ Stephen completed his Ph.D. in my lab and is one of the most outstanding researchers to emerge from my lab.

◆ *Susan was my graduate student and ranks among my very best students.*

Second paragraph:

◆ In my lab, Dr. Hoffman

◆ *As a student, Susan*

◆ Dr. Hoffman initiated

◆ …

◆ Dr. Hoffman brought that work to fruition

◆ …

◆ senior author

◆ *coauthor*

◆ Dr. Hoffman proved himself an outstanding researcher and valued colleague.

◆ *Her high productivity as a graduate student is particularly remarkable because she had two children while in graduate school and her husband is a resident in emergency room medicine.*

Third paragraph:

◆ Dr. Hoffman continued to produce original research as a postdoc.

◆ *Susan continued her record of excellent work as a postdoctoral student.*

◆ Although that work is not yet published, it has a bright future. The project was technically challenging, but Dr. Hoffman has surmounted all of the obstacles and a genetic and biochemical analysis of the *spoW* allele and its product will be ready for publication soon. Given Dr. Hoffman's past record in publishing research, I have no doubt that his work will be published in a top-tier journal.

◆ *Susan has been slow to publish this work and therefore has no publications from her three-year postdoctoral study. No doubt her family responsibilities have contributed to this delay.*

Fourth paragraph:

◆ a capable mentor and teacher

◆ *an able mentor and a sterling classroom teacher*

◆ He has supervised three undergraduate researchers. He is clearly able to transmit his passion and talent for research to young scientists.

◆ *She has three undergraduate researchers who have all coauthored publications, which is indicative of the excellent mentorship they received from Susan.*

◆ Dr. Hoffman is one of my few colleagues to whom I will entrust my class when I travel.

◆ *Of all of my students, I felt the most comfortable asking Susan to cover my classes for me when I was out of town because I knew she would do a great job*

◆ Dr. Hoffman was also a terrific citizen and a leader in my lab.

◆ *Susan was also a cooperative and reliable lab citizen.*

◆ He … was resourceful, and took initiative to maintain equipment and ensure that safety standards were met. He took on many of the responsibilities of a faculty member and excelled in everything he did.

◆ *She … conscientiously followed through on all that was asked of her to maintain equipment and ensure that all safety standards were met.*

Fifth paragraph:

◆ He is one of my finest colleagues—an outstanding researcher and talented teacher.

◆ *She is one of the best students I have seen and is a talented teacher and mentor.*

◆ He has demonstrated an uncanny ability …

◆ *She has an uncanny ability …*

◆ I expect him to be one of the leading researchers in his field.

◆ *I expect her to continue to be as productive and creative as she was as a student in my lab.*